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Forthcoming Events.

JUNE 4 to 6.

Institute of British Foundrymen.—Annual Convention at Newcastle.

JUNE 4-5.

British Empire Mining and Metallurgical Conference.—At Wembley.

JUNE 19 to 28.

International Foundry Trades Exhibition.—At Bingley Hall, Birmingham.

JUNE 25 to 27.

Foundry Technical Congress.—Bingley Hall, Birmingham.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

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Clearing the Air.

Professor Campion in recent lectures has commented upon this definition of semi-steel as originated in this column. He characterised the definition as fairly good and as one forming a basis for discussion. He did not, however, substitute an alternative description and, we fear, he has only complicated the issue. This is because he has pointed out the desirability for a pearlitic matrix. Here it is essential that we should digress for a moment and consider an allied material—pearlitic cast iron. This material came into the foundry limelight by our publication of a translation of an article by Professor Bauer, dealing with a material patented by Herr Diefenthaler and made by the Lanz foundry in Germany. The only admissible translation of the German appellation was "Pearlitic Cast Iron." The material was not new, only the method of its production was novel, and confusion was immediately introduced by a Swiss engineer, who apparently produced equally good results with electrically-made cast iron.

At the moment, then, there are two pearlitic cast irons which admit of the following definitions: (*a*) Diefenthaler's pearlitic cast iron is cast iron which has small-fine or nodular graphite evenly disseminated in a pearlitic matrix and produced by the heat treatment of moulds according to Diefenthaler's patent specification; (*b*) ordinary pearlitic cast iron is exactly the same material as Diefenthaler's pearlitic cast iron, but made by any other process. We propose, therefore, in future to allow definition (*b*) to be considered as the essential, and if the Diefeuthaler material is to be referred to, then we will qualify pearlitic cast iron by the word "Lanz," a method already used in the German technical press.

Thus pearlitic cast iron by right of common international usage is a cast iron with which is associated small-fine or granular graphite evenly disseminated throughout a pearlitic matrix. The object of our digression should now be clear. If Professor Campion's inference is accepted, then there is but little, if any, difference between pearlitic cast iron and semi-steel cast iron. Apparently the only definable—but still overlapping—difference is that semi-steel cast iron must be made by the addition of steel to the charge during its manufacture, whilst pearlitic cast iron can be made by any process. We suggest, therefore, that it would be advisable for the sake of clarity to let our definition of semi-steel cast iron stand *almost* unmodified, and allow Professor Campion's inference as to the matrix be retained for the superior product, namely, pearlitic cast iron. In suggesting that our definition of semi-steel cast iron should stand unmodified, we have qualified it by the word "almost," because the definition does not include the material which has the most right to the name semi-steel, that is, an alloy made by adding liquid steel to cast iron, as is regularly carried out by Mr. A. Harley. We suggest, therefore, that the definition should now read:—Semi-steel cast iron is a cast iron which has had its graphitic structure modified—that is, made finer or nodular by the incorporation of steel into the charge during its manufacture, or suitable liquid steel added to liquid cast iron before teeming.

It is now fairly obvious that if foundries are making the highest class of semi-steel, such as was referred to by Professor Campion, then they have the right to call it by and sell under the name of pearlitic cast iron. If it sounds the death-knell of the expression semi-steel, so much the better.

Some Notes on Wasters.

By J. E.

There is not the least doubt that if foundrymen were *bold* enough to publish all the failures they encounter we should not only have a permanent record, but a fund of information which would be helpful and instructive to the industry. But who is the man who dares to do so? Most moulders fight shy of speaking of their own failures, lest they be considered inferior craftsmen.

Frequently we are told that failures properly treated and finding the true cause of the failure, will ultimately lead to success.

Even in the Foundry Trade Journal, January 24, 1924, a leading article asked that "if moulders conscientiously filled in a book daily, and had the misfortune to be associated with a batch of wasters, he would be in a position to give his foreman an opinion."

Perhaps there is not a moulder living who has never made a waster—it is so easy to make wasters. The least little detail omitted and the whole mould is spoilt. After all, what are wasters? Just for a moment let us consider this question as spoken of in other departments.

Non-Foundry Wasters.

If the designer makes a waster it is called "an error of judgment." The draughtsman in turn calls his wasters "slight miscalculation of figures." The patternmaker says waster was due to indistinct figures on the drawing, or misunderstanding or inadvertence in reading the drawings. The machinists generally attribute their wasters to hard castings, blow holes, cracked castings, etc. The clerk calls his wasters clerical errors, and so on. But, when a failure occurs in the foundry, no matter from whatsoever cause, it is cruelly termed "waster."

All the terms applied to wasters in the various departments, other than the foundry, express less severe judgment. Why this should be is exceedingly difficult to understand. The moulder is every bit as conscientious as the other workers and has far more difficult problems to solve than any other craftsman. It is impossible to think the moulder would make a waster wilfully or carelessly.

Then let all be a little more kindly disposed towards the moulder, and try to understand his trials and troubles.

Some Typical Examples.

The following is a faithful account, as far as memory serves, of wasters the writer has heard of, seen, or made, and will cover a period of many years.

Tramway crossings were being made, and the groove in them for the flange of the wheel to run in, was formed a cod of sand, to be lifted by the top box. This cod was sprigged all along, yet there was frequently a "washing-away" and many castings were lost, until pieces of hoop iron were substituted for the sprigs, and the castings then came out satisfactorily.

Steam Cylinders.

Small steam cylinders were being made, and it would be extremely interesting to the present-day moulder to have seen the method of moulding that was adopted in consequence of the manner in which the pattern was made. It necessitated the cylinder being moulded on end, and the steam chest was moulded, not cored. To-day it is not far wrong to state that at least six castings would be made while one was being made the old way. Great care had to be taken in setting the loam port and exhaust cores into the sand steam chest part. It was common to find one of these cores had moved in the casting, particularly the top port-core. This trouble was ultimately mastered by fixing a small iron loop in the body or bore core and then wiring the top port-core to it. All these difficulties are removed now, as the pattern is made in halves and the steam chest cored with much better results.

Edge Runners.

Edge runners gave trouble through cracking. Cores were left in the casting, of course, vent-holes were provided, and as soon as the mould was poured and the metal set, the top was taken off and the vent-hole cores taken out and then metal poured, except one, and this was left open until all the gas had been burnt out. Yet the casting would crack across the vent-holes. It was decided to leave the last vent open much longer to give the gas a better chance to exhaust itself, then stop the vent-hole, and this proved successful.

Columns.

In a jobbing shop columns were being made. They were about 14 ft. long, the cross section being circular with an H section attached thus (H) A coke bed was made and the usual method adopted. Yet the bottom cod would wash away, although some of these were dried and strong sand used. Ultimately a much weaker sand was used, and this proved satisfactory.

Angle Plate.

A large angle plate was undertaken about 12 ft. × 8 ft. where the greatest strain came at the time of casting, provision was made by ramming bars of pig-iron at small intervals, thus making a good sound bottom-part. When all was ready to cast no sooner had the metal been poured in than it was blown out. The next day an investigation was started, and it did not take long to discover the ground at the lowest point was very damp.

The next one was made and inspected when ready to close, and was found still damp. So four deep holes were dug outside the mould and fires put in these, to draw the damp from the mould, which undoubtedly saved the casting.

Gas Brackets.

In the days gone by when gas brackets were much in requisition, especially by public-houses, great trouble was experienced in getting the metal to lay quietly on the wrought-iron gas pipes which were cast in the brackets. Many castings were wasted. Red lead and turpentine, applied wet and then dried, gave the best results generally. Even with this the castings would sometimes blow. One moulder used to bring in a medicine bottle of some clear liquid, and by using this on the gas pipe, applied in the same manner as the red lead and turpentine, very satisfactory results were obtained. His confrères could never find out the exact ingredients other than borax was the base after being powdered up and boiled.

Ram Castings.

In making a ram about 14 ft. long × 12 in. dia., moulded on end in a pit, which was filled in with rammer sand, the metal broke out of the mould at the bottom and exhausted all the metal in the ladle. New metal was rushed up and poured in, but it all went away again. The next day the pit was dug out and the old-fashioned jib crane shackled into the box. The men started to hoist, but could not move the box; more men were put on to the handles, and strained every muscle until they broke the barrel of the crane, necessitating extensive repairs. In the meantime the pit was cleared of sand down to the bottom of the moulding box. Then a jack was fixed as near the top of the pit as possible to push over the box. It was then discovered the metal had broken through the joint of box and worked down into the virgin soil. Such metal was never recovered.

The next one was insured against running out by using solid-bottom box for the bottom part of the ram.

Horizontal Engine Bed.

When making a large horizontal engine bed about 4½ tons, the runners were pitched as low as possible. A curious thing happened when the casting was stripped, one corner of the bearing block simply fell off, revealing quite a clean fracture like a cold sheet. The only conclusion arrived at was the metal ran into the corner of the block, then by some freak stopped running in that direction sufficiently long for that piece of metal to

become solid, and when the other molten metal came along in that direction it would not fuse on to the piece that was already there. This was not sufficiently serious to scrap the casting. The loose piece was drilled, tapped and studded on to the bed, and quite a good, sound job was made of it.

Throttle Blocks.

Quite a number of throttle blocks were being made in a large engineering works, and great difficulty was experienced in getting them round and solid throughout. These blocks were about 12 in. dia. × 4 in. thick, and had to be machined all over and drilled in several places. Although the outside was always fairly good, the inside was nearly always spongy, which rendered the blocks useless.

It mattered not which way these were moulded and cast. Nor did it make any difference whether heads were cast on or not, bad results were nearly always obtained. Success was achieved by casting in mild steel tubes where holes were required, but even this was not wholly satisfactory. Ultimately the design was altered and there was no more trouble.

Bed Plates.

A large bed plate was undertaken by a London foundry for 2-off. This job ought not to have been taken by this foundry, as it was too large for it, not so much on account of its weight, which was about 8 or 9 tons, but because of its size. It was moulded in the ground in dry sand, and that very strong. It occupied eight men about two or three weeks to mould, and was about 10 ft. from the floor level to the lowest foot of the bedplate.

When the 10 tons of metal was poured into the mould all was quiet for about 12 seconds. When the metal in the runners and risers began to show a slight agitation, which gradually grew more pronounced, until as much metal as was held by the runner and riser cups was blown with terrific force to the roof of the foundry. This was repeated until all the molten metal was blown out of the mould. No serious injury was felt by any of the men, although very few got off quite free from burns of some sort. Gangs of men worked all through the night to clear away the *débris* and prepare the ground for another mould and investigate the cause of this disaster. The conclusion arrived at by the men in the shop—by the way, they are the best to deal with a matter of this description—was that the pressure of metal was so great at the lowest point of the mould that it moved the loam back plate—which was wedged by mild steel bars to the virgin soil—ever so little, yet enough to allow the metal to escape. The soil being damp, generated steam, which by its expansive force shot the molten metal back through the mould and out of the runners and risers.

The second casting was a success, although it had to be made in much the same way, only more precaution taken with the back plate and its security.

A Cylinder Defect.

A curious defect occurred in a cylinder weighing about 5 tons 10 cwts. This cylinder was cast crown down, and as it was for a Government boat, it had to have a head cast on about 18 in. deep and the whole width of the flange. After being trimmed it gave a very fine appearance, and all concerned were quite satisfied. But, when after nearly all machinery was finished and the finishing cut was taken over the flange, a draw-hole was revealed about a sixth of the diameter of the flange and 2 in. deep. Yet the head was fed by large risers and feeding rods. However, it was dumped back into the foundry, with instructions to make another. After many years' thought upon that incident, it still remains difficult to understand why this defect should have occurred. The metal was the usual good cylinder mixture, *i.e.*, Graybrook, Goldendale and Warners, with one-third good scrap, and was in splendid condition at time of casting.

After the usual inquest had been held it was decided to try to burn it. Large box parts were brought together and a coke fire put in the bottom. The casting was then lowered on to this fire, which was built up all round the outside, and additionally a fire put inside until the casting was red hot. Then new sand was rammed all round the flange and the defective part brought to a bright red heat. A block of wood had been cut sufficiently large to cover the hole and about 10 in. high. This was placed upon the defective part and rammed up with new sand. Fifteen cwts. of nice hot cylinder metal was slowly poured in from a height of about 2 ft. 6 in. Provision was of course made for the overflow, blacking was covered all over this patch after casting, and then the whole covered with sand and left for 1½ days, when the casting was taken out and inspected. It was considered sufficiently good to cut off this head and carry through another inspection, after which it still held good, so it was finished off and not a blemish was discernible, only to the foundryman, and he could see the line of demarkation of the old and new metals.

This is still considered one of the best jobs of "burning-on" ever performed.

Amateur Roll Making.

An attempt was made to make a roll for a shipyard rolling mill, despite the fact that the management were advised not to undertake this job, but to order one from established reputable roll makers. There was no tackle to make this properly, so the management decided to mould and cast it horizontally. Its weight would be about 2 tons, for it was about 18 in. dia., 4 in. thick. The core was 10 in. dia. in the centre, running through each end at 6 in. dia.; packing was built up in the core on to the 4 in. core barrel to take the studs. These studs, of cast iron, were 5 in. dia. All things were secured in the usual way and the pouring carried out successfully. The casting appeared quite satisfactory when it was taken out of the sand, and also after it was machined. But when it was put into operation for a trial it snapped into two pieces. It was then discovered that the top studs had actually melted and allowed the core to float, leaving very little thickness along the top of the casting. The management then decided to buy one from experienced makers.

Death of Prominent Foundryman.

We regret to announce the death of Mr. J. S. Morehead on April 14 at his residence, Hillview, Pollards Hills West, Norbury, S.W.16. Mr. Morehead had been in failing health since his retirement some two or three years ago. A patternmaker by trade, Mr. Morehead served his apprenticeship with Messrs. Cammell, Laird & Company, Limited, of Sheffield. For some years he was foreman patternmaker to Messrs. J. Stone & Company, Limited, of Deptford. He left there to take charge of the foundries of Messrs. Willans & Robinson, of Rugby. It is thought by many that he was the first to introduce the use of oil for coremaking, but at any rate, he was one of the first to make a success of the manufacture of automobile cylinders. Whilst he was in Rugby he strove continuously for the improvement of the science of foundry work and the status of those engaged in the industry, and his name will always be remembered as a founder of the Institute of British Foundrymen. His last position was that of general manager of Messrs. Henry Watson, Limited, of Walkergate, near Newcastle—a position which failing health caused him to relinquish. Whilst he never took office in the Institute, he retained his interest to the end, and regularly attended the meetings of the London Branch. On behalf of the foundry trade, we offer to his widow and family sincere condolences.

The Newcastle Conference.

We are now in a position to announce that the Exchange Paper to be presented on behalf of the Association Technique de Fonderie (France) is to be prepared by Mons. P. Chevenard, and carries the title "A Dilatometric Study of Cast Iron." Mr. Van Aarst has decided to confine his remarks to "Economical Cupola Melting," instead of dealing with the wider subject of Dutch Foundry Practice. The complete list of Papers is now the above, and "The Formation of Graphite," by L. Northcott, M.Sc. (Birmingham); "Non-Ferrous Alloys in Marine Engineering," by A. Logan; (Newcastle-on-Tyne); "The Production of Castings in Permanent Moulds," by R. J. Anderson (A.F.A. Exchange Paper); and "The Technical Side of Oil-Sand Cores," by C. W. H. Holmes, M.Met. (Birtley).

Popular Branch Secretary Resigns.

Mr. W. A. Macdonald, who has been the honorary secretary of the Sheffield Branch of the Institute of British Foundrymen for the last four years, resigned his office with the close of the present session. He is to be replaced by Mr. R. Village, of Chesterfield.

He referred to his work in his report given to the annual meeting of the branch in the following terms :—

"I am extremely indebted to the past Presidents for their ever-willing assistance and their kind indulgence, and to the Council and members for their kindly co-operation in the work of the branch. I must also thank the directors of the Brightside Foundry and Engineering Company, Limited, for the assistance they have afforded me in the corresponding and detail work of the branch. I wish also to put on record that I could not have done this work on my own without the help of my assistant on the staff, and I hope that my successor, Mr. Village, will be as fortunate as I have been in the help I have received.

"When I took over the secretaryship in 1920 the membership was as follows :—Sixty-six members, 88 Associate members, six Associates; total, 160.

"At the present moment we have a total of 164 members, who have paid their subscriptions for 1923. The arrears of subscriptions up to the end of 1923 total £59 17s., some of which will have to be wiped out, but in spite of this the branch has never been in a stronger financial position.

"We have tried to create interest in the Rotherham district, and we have been successful in securing a few members there, but the question will have to be thoroughly discussed before anything further is done.

"I hope that now the Institute is presenting the members and Associate members with membership certificates that it will mean the influx of many more new members. We keep losing members owing to death (5), transferring to other branches (11), illness, shortness of work, and loss of interest (51), but I am sure if each one of us tried to enrol another member our branch would be the strongest in the country. We have enrolled 76 new members, including six subscribing firms, during my term of office.

"I sincerely hope that members will give Mr. Village their friendly support and interest, and I am sure that will be sufficient to make his duties very much lighter than they otherwise might become."

Mr. Macdonald is to be congratulated on the way he has conducted the branch during four years of unparalleled trade depression.

Foundry Queries.

Locomotive Cylinder Mixture (Page 228, March 20).

The question raised by "Cylinder" is a very important one, and has not been quite met by the various correspondents. A large amount of investigation and experiments have been carried out by railway engineers upon loco. cylinder castings, and a very exhaustive research has just been completed in America. Unless air furnace melting is resorted to, added steel scrap has been found unsuitable for these castings; if such melting is available, 15 per cent. can be added. A strong and sound iron is required, low in graphite, so as to withstand the very high temperatures and not have any tendency to "grow." The mixture should be composed of materials estimated to yield casting analysis as follows:—T.C., 3.30; silicon, 1.25; sulphur, 0.124; phosphorus, 0.47; and manganese, 0.58 per cent. A mixture consisting of cold-blast irons, 30 per cent.; Scotch iron, 20 per cent.; North Staffordshire iron, 10 per cent., and good cylinder scrap, 40 per cent. should obtain the above results. But for this class of work good cupola practice is essential, and care taken in casting and cooling.—Disce-Dosce.

Ventilating Oil Stoves:

Can any of the readers of The Foundry Trade Journal enlighten me as to the advisability or otherwise of ventilating a core stove? My old foundry manager is most punctilious to have it almost hermetically sealed.

In a little stove the cores become very dry, but only after some considerable baking.

I have a very large stove, which has been built for 50 years, but only used occasionally for heavy jobs, and in which the doors do not fit as well as in my modern stove, but the cores dry remarkably well.

I am thinking of putting in an exhaust ventilator to my small stove. Have any of your readers experience of these, and can they tell me the results of ventilating a stove by mechanical appliances or by an orifice left at a suitable place in the crown? I shall be grateful for any information.

Iron Founder.

Sand and Coke (Page 308, April 10).

The question put by "G. F." regarding sand and coke is somewhat like the proverbial one about the length of a piece of string.

Everything in this case depends on the quality and finish of the castings being produced. Is "G. F." making sash weights and railway chairs or motor-car cylinders and valve bodies?

Coke ratios may vary from 5½ to 1 to 11½ to 1, depending on the class of work, cupola, etc., and both extremes may represent excellent practice.

Sand consumption varies enormously according to finish, etc., desired. For high-class work the criterion should be good sand and plenty of it, and run the cupola with sufficient coke to give intensely hot metal.

Where high-class work is being produced, the sand and coke costs have very little bearing on the final cost of the castings.—F. W. R.

"G. F." should state exactly the information he requires as to his sand consumption, whether he requires details of facing or core mixtures, or advice as to moulding methods. To give any advice it is necessary to know what plant he uses.

With regard to core consumption, an average ratio is 1 to 10, but if he will give inside diameter of his cupola, size and number of tuyeres, blast pressure and volume of air, with details of charges (coke and iron), advice can be given.—Disce-Dosce.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Professor Campion's Paper on Semi-Steel.

To the Editor of The Foundry Trade Journal.

Sir,—In 1914 I took up McLain's course on this subject, but did not proceed with the matter until 1919, and have been making from 20 to 60 per cent. semi-steel mixtures, with up to 35 per cent. for general or engineering castings to stand up to high pressures. The 40 to 60 per cent. is for chill work and the lower percentages for machine work of varying character, but with uniformly improved results over straight iron. There are jobs innumerable that present difficulties in grey iron that are alleviated by the use of steel when the cupola is controlled. One of the chief points is the homogeneity of the metal with widely varying sections when steel is used. Almost any test can be met; in any case, any reasonable test can be beaten. There are two points with which I disagree—one, on information from a very reliable source, that all the turnings and borings made by a large firm of car manufacturers are used up in cupola, and the second, the speed necessary in running semi-steel. In making chilled work with large percentages of steel undoubtedly speed is essential, but up to 35 per cent. we find the metal holds up as long as straight iron when the manganese content is suitable, and most of our moulds are run through riddle or strainer cores with a good downright and a git as large as the job will allow. Finally, we rarely use risers.—Yours, etc.,

Leicester. "Progress."

The Lancashire Metal Flux Company, of Garden Street, Heywood, Lancs, has developed and placed upon the market a flux which is claimed to be equally suitable for brass, iron and steel foundry work.

The Influence of Composition and Rate of Cooling upon the Microstructure and Physical Properties of Cast Iron.*

By H. H. Beeny, M.Met.

Introduction.

In this Paper it is proposed to deal first of all with the constitution and physical properties of the iron-carbon alloys as a whole, commencing with pure iron, passing through the steels, and ending finally with white cast iron. The microstructure of each broad type will be illustrated. In this way it is hoped that the comparatively complex structure of white foundry irons will be made clear. This deals so far with the metastable iron, iron-carbide system, and will be followed up by a consideration of the influence of silicon and other elements, and also rates of cooling upon this system in relation to ordinary foundry irons.

As will be seen, this Paper deals with some of the theoretical principles underlying the manufacture of cast iron rather than with the practical details of any particular foundry problem. It would seem that no apology is needed for the introduction of theory, as the most rapid improvement can only be effected when theory and practice are considered side by side.

The Iron—Iron-Carbide System.

Fig. 1 indicates the physical changes which occur when pure iron-carbon alloys solidify and cool down to ordinary temperatures with moderate slowness. The vertical line represents temperature and the horizontal composition in regard to carbon. The vertical line is marked to show the

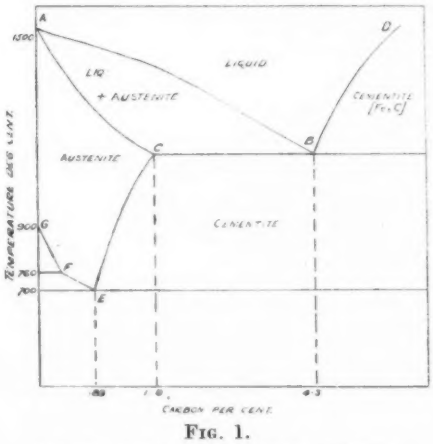

FIG. 1.

The Iron—Iron-Carbide Equilibrium Diagram.

changes that occur in pure iron. When pure iron, free from carbon, cools in the liquid state, solidification takes place at approximately 1,530 deg. C. Innumerable minute crystals form within the liquid mass. These crystals, each possessing a definite geometrical form, grow towards one another until they meet and the whole mass is solid. When the mass is nearly solid obstruction to free growth is offered by surrounding crystals so that the final shape of a crystal as viewed under the microscope is that which is mutually imposed by the crystals surrounding it. Instead, therefore, of pure geometrical forms, there are polygonal outlines which bear no direct relation to the very definite arrangement of the atoms within the crystals themselves. Immediately on solidification the atoms are arranged as a face-centred cubic lattice; that is, considering one unit of the lattice, there is one atom at each corner of a cube and one in the centre of each face. Such an arrangement is called gamma-iron and persists down to approximately 900 deg. C. At this temperature a rearrangement of the atoms takes place, the exact nature of which is still obscure, but which gives rise to what is known as the beta modification of iron. This is stable down to 760 deg. C. At 760 deg. C. the metal begins to acquire magnetic properties and the atoms take on a body-centred arrangement; that is, one atom at each corner of a cube and one at the centre of the cube. This structure, which represents that of alpha-iron, is stable, as far as present knowledge goes, down to tempera-

FIG. 2.

Polygon Structure of pure Iron x 150 (Rosenhaim).

tures far below the freezing point of water, and it is alpha-iron which is seen therefore under the microscope. The atomic structure of pure iron is only mentioned in order to illustrate that alpha, beta and gamma are only names which signify different arrangements of the same atoms. This matter is important, however, in so far that carbon, as carbide, is soluble in gamma-iron but to all intents and purposes completely insoluble in alpha-iron. The structure of steels and cast irons cannot be understood without this fundamental

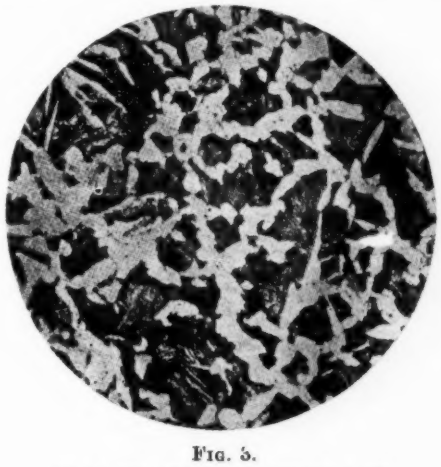

FIG. 3.

0.5 per cent. Carbon Steel annealed x 100.

conception. Fig. 2 shows the structure of pure iron; such a structure is shared by all pure metals and homogeneous solid solutions.

When carbon up to 4.3 per cent. is introduced the mechanism of solidification remains the same as that hitherto described, but the solid first formed consists of a solid solution of iron carbide, Fe_3C, in iron, and as the carbon in the alloy is increased the freezing point is progressively lowered. The initial freezing points of these

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* A Paper read before the Coventry Branch of the Institute of British Foundrymen, Mr. C. Dicken in the chair.

alloys are shown by the line AB on the iron-carbon diagram and the composition of the solid which forms at any temperature by the line AC (Fig. 1). It will be seen that as the temperature falls the metal solidifying becomes increasingly rich in carbon. Immediately after solidification, therefore, there is a progressive difference in composition between the cores of the crystals and the last parts to freeze. During and subsequent to solidification diffusion of the carbide is taking place, and at some temperature below the line AC these differences in composition disappear, and the whole mass then consists of homogeneous

Fig. 4.
Eutectoid Steel (C. 0.89 per cent.) x 600

crystals of solid solution similar in appearance to those shown by Fig. 2. This solid solution, which is known as austenite, in a steel containing less than 0.89 per cent. carbon, persists until the line GFE (Fig. 1) is reached, when pure iron or ferrite continuously separates with falling temperature until the residual solid solution reaches the eutectoid composition. At just below 700 deg. C. this residual solid solution breaks down into pearlite. So that all alloys containing up to 0.89 per cent. C. will consist of varying proportions of ferrite and pearlite. Fig. 3 shows the typical appearance of a 0.5 per cent. C. steel with

Fig. 5.
High Carbon Steel x 120.

white ferrite grains and black pearlite. Fig. 4 gives the characteristic laminated structure of the pearlite at a much higher magnification. In this case the steel contains approximately 0.89 per cent. C. and the whole field consists of pearlite.

Between 0.89 per cent. C. and 1.8 per cent. C. the same principles hold, but the carbide, Fe_3C, or cementite, is precipitated instead of ferrite. The line CE (Fig. 1) shows the temperature at which this commences for any particular composition. Fig. 5 illustrates the typical structure obtained, grains of pearlite with cementite at the boundaries, and where the cooling is moderately rapid needles of cementite within the grains themselves. Above 1.8 per cent. C. a marked change of structure occurs. Such an alloy deposits a solid solution along the line AC (Fig. 1) until the remaining liquid attains the eutectic composition 4.3 per cent. C., which occurs at 1,130 deg. C. At this temperature the liquid freezes in a form which may be likened to a bundle of rods. Fig. 6 shows the structure of a white cast iron containing 3.63 per cent. C. and 0.235 per cent. Si. The large dark areas represent the first portions of the metal to solidify and consisted originally of the austenite solid-solution. Assuming that sufficient time has been given for diffusion to take place, this solid solution would contain approximately 1.8 per cent. C. when the eutectic began to solidify at 1,130 deg. C. In cooling down the carbide, cementite was precipitated in exactly the same manner as with the high-carbon steel previously mentioned, the residual solution forming pearlite. The separated cementite can be seen as a white rim round these large pearlite areas. Between these areas is the eutectic, the last portion to solidify, with its mingled honeycomb and zebra patterns. The exact appearance of any particular area, of course, depends upon its orientation to the plane of the micro-section. The two constituents of the eutectic were originally austenite containing 1.8 per cent. C. and cementite. The austenite has converted to pearlite, which shows up as thin, dark lines and dots, and the cementite remains unchanged as the white ground mass. It will be

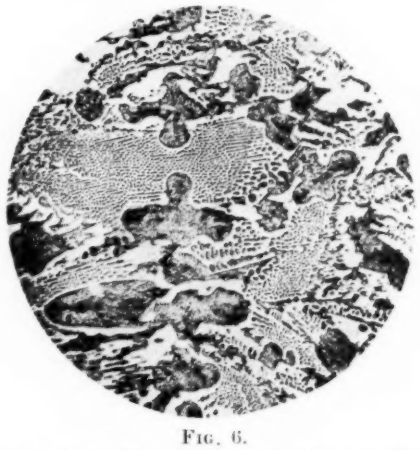

Fig. 6.
Hypo-eutectic White Cast Iron. C. 3.65 and Si 0.235 per cent. x 100.

seen that this white-iron structure contains neither free ferrite, that is pure iron, nor graphite, but consists entirely of pearlite and cementite. Further increases of carbon would increase the amount of eutectic until at 4.3 per cent. the whole field consists of eutectic. With a still further increase of carbon, long straight bars of cementite would first freeze out from the liquid alloy in accordance with the line BD (Fig. 1), and the eutectic would solidify between them.

This concludes the necessarily brief summary of the metallography of the pure iron-carbon alloys. The physical properties as shown by the Brinell, tensile strength and elongation per cent. bear a very close relationship to the structures we have seen. Pure iron is a soft ductile material very similar to copper. It has a Brinell figure of 90, a tensile strength of 17 tons per sq. in., and an elongation of 50 per cent. on 2 in. The iron carbide, cementite, in its massive form is intensely hard and brittle; it has a low tensile strength and no ductility at all. Cementite is somewhat like glass. Glass in ordinary thicknesses is, as is well known, brittle and inflexible, but drawn into thin threads or sheets it loses some of its brittleness and becomes flexible and elastic. In pearlite the cementite exists in microscopically thin sheets, which greatly increase the strength and at the same time do not seriously diminish the toughness of the material. The physical properties of pearlite itself may be inferred by those of an annealed all-pearlitic steel, *e.g.*, maximum

stress 56 tons per sq. in., elongation 17 per cent., and Brinell No. 220. In white cast irons, on the other hand, the cementite exists as has been shown in comparatively large and brittle masses, which render the metal unmachineable and very seriously impairs the tensile and transverse strength.

The Introduction of Silicon into Iron—Iron-Carbide Alloys.

Silicon is soluble in iron, as iron silicide (Fe_2Si) up to approximately 20 per cent. by weight of silicon; in ordinary proportions, therefore, it cannot be detected directly under the microscope. Up to 5 per cent. Si, added to commercially pure iron, increases the tensile strength; beyond this amount a decrease occurs. Four per cent. Si reduces the elongation down to practically nil and gives a coarsely crystalline fracture. It seems evident, therefore, that the brittleness and lack of ductility of grey foundry irons is in part due to silicon in solid solution.

The iron—iron-carbide system is really only partially stable; there is a tendency for the carbide to break down into iron plus graphite. In low-carbon steels such a possibility is negligible, but the instability becomes more and more real as the amount of carbon is increased. Fig. 7 shows the graphite modules surrounded by areas of ferrite, in a high-carbon steel which has undergone decomposition. Such secondary graphite is formed at temperatures well below the solidification temperature of either steel or cast iron. Fig. 8 gives the structure of black-heart malleable after the annealing treatment. Both cases show the nodular form of graphite. Fig. 9 illustrates a very extreme case of primary graphitisation. Such a structure is only possible where both total carbon and silicon are high and the rate of cooling over the solidification range is slow.

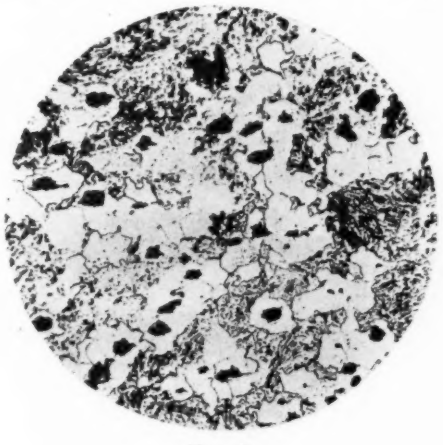

Fig. 7.

1.25 per cent. Carbon Steel Carbide partially decomposed x 150 (Sauveur).

Professor Turner has published curves which show that for an experimental series of irons containing approximately 2 per cent. of carbon, the maximum softness and machinability occurs at 2.5 per cent. Si. At less than this amount the irons are harder owing to increased combined carbon, and at more than 2.5 per cent. owing to the hardening action of silicon itself in solid solution in the ferrite. It should be understood, however, that the position of the minimum is modified by the rate of cooling, as governed by the size of section and the type of mould, and by the composition in regard to total carbon, together with the proportions of manganese and sulphur. Of these the most important are rate of cooling, which will be dealt with later, and total carbon. It has already been indicated that the higher the carbon the more readily does graphitisation take place; this can be readily understood when it is remembered that the velocity of a balanced reaction is proportional to the concentration of the reacting bodies. High total carbon decreases the shrinkage but favours the formation of large graphite flakes and is therefore to be avoided. In practice the total carbon depends upon conditions in the cupola and the amount of silicon present; all normal foundry irons, in fact, approximate to the eutectic composition, which itself varies according to the amount of silicon present.

The figures in Table I, taken from those obtained daily at the works where the author is employed, summarise the effect of silicon on t physical properties. Samples are taken from each grade of iron and cast in the form of Keep's bars ½ in. sq. between cast-iron yokes having chill faces exactly 12 in. apart. Apart from any slight variation in casting temperature, the rates of cooling are therefore constant for all grades of iron.

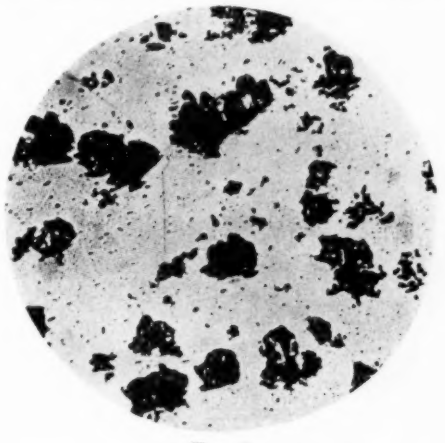

Fig. 8.

Secondary Graphite in black-heart malleable Cast Iron x 100 (Sauveur).

Table I.—*Showing the Effect of Silicon on Grey Iron.*

Analysis.		Shrinkage, per ft.	Transverse, cwts. per sq. in.	Chill.
T.C.	Si.	Inches.		Inches.
3.25	3.0	0.142	27.0	1/32
3.44	1.93	0.154	28.5	3/16
3.51	1.60	0.158	30.0	5/16
3.44	1.13	0.171	28.5	1/2

Fig. 9.

Extreme case of primary graphitisation x 100 (Sauveur).

Manganese and Sulphur.

Before passing on to a more detailed consideration of the effects of rates of cooling, it would be well, perhaps, for the sake of completeness, to outline briefly the parts played by sulphur, manganese and phosphorus.

Sulphur existing as ferrous sulphide, FeS, is soluble in molten iron but insoluble in solid iron. On freezing the sulphide is concentrated in the last portions to solidify, and appears therefore in star-shaped masses between the crystal grains. A

steel containing free iron sulphide fractures readily along the crystal boundaries, particularly in the hot state, owing to the presence of this weak and easily fusible constituent. Manganese sulphide, MnS, on the other hand, has a high freezing point and is completely insoluble in both liquid and solid iron. The addition of manganese to a steel or cast iron causes the following reaction to take place:—

$$FeS + Mn \rightarrow Fe + MnS.$$

The manganese sulphide thus formed freezes quite independently as small scattered globules, which appear dove-grey under the microscope.

Fig. 10.

Phosphide eutectic and graphite in matrix x 100. It contains Gr 3.06, SS 0.08, and P 1.36 per cent.

In medium- and high-carbon steels and cast irons these globules actually freeze before the metal itself. Under such conditions the sulphur is inert and has little injurious effect upon the mechanical properties. It should be mentioned, however, that 2½ times the theoretical amount of manganese is required to carry the reaction given above to completion; as the atomic weight of manganese is nearly twice that of sulphur, this means in practice that one requires of manganese five times the percentage of sulphur, *e.g.*, 0.1 per cent. S. requires as a minimum 0.5 per cent. Mn in order to render it harmless.

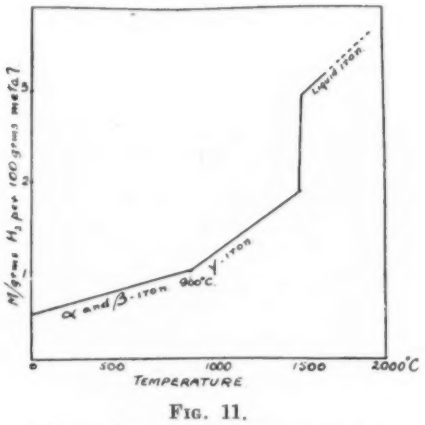

Fig. 11.

Solubility Curve for hydrogen in pure Iron.

In cast irons, however, sulphur appears to exist additionally in association with the carbides either as a compound or in solid solution in the carbides. Experiments upon an iron of the following composition are recorded by Dr. Stead:—

C.C., 2.98; Gr., nil; Mn., 0.29; Si., 1.89; S., 0.27; and P., 1.62 per cent

The iron was quite white. The experimenter examined the carbides analytically and they were found to contain 0.12 per cent. S. He then remelted the metal and added sufficient manganese to leave 1 per cent. in the finished state. The fracture of this remelted alloy was quite grey, the combined carbon falling from 2.98 per cent. down to 0.6 per cent. This experiment and others along similar lines led Dr. Stead to conclude that in the absence of sufficient manganese sulphur crystallises with the carbide and renders it more stable. It is probable that high sulphur acts particularly in preventing the breakdown of the pearlitic carbide, the structure of a high-sulphur "pearlitic cast iron" usually showing large flakes of primary graphite imbedded in a completely pearlitic matrix.

The action of manganese in softening a white high sulphur iron can only be explained along the foregoing lines, as manganese itself, owing to the greater stability of its carbide, has a distinctly whitening effect.

Phosphorus.

Phosphorus exists as the phosphide Fe_3P, and as such is soluble in pure iron up to 1.7 per cent. of phosphorus. Professor Arnold tested an iron containing 1.36 per cent. P., but low in carbon and impurities, and obtained a maximum stress of 29 tons per sq. in. The elongation and reduction of area were nil. The metal was harder than pure iron, but extremely brittle and completely lacking in ductility. The weakness of phosphoric metal is strikingly revealed by any form of impact test, even when the ordinary static tests give apparently good results.

In cast irons containing 3.5 per cent. of carbon the solubility of phosphorus is reduced to 0.31 per cent., and amounts above this solidify as a

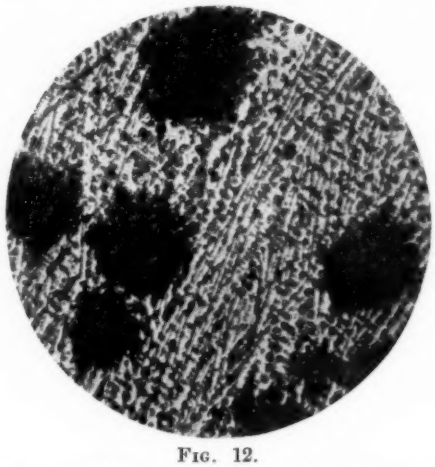

Fig. 12.

H Series. Faintly mottled structure of Iron containing T.C. 3.56 and Si 1.39 per cent. cast as ¼ in. bar in green sand and etched x 100.

ternary eutectic consisting of iron phosphide, iron carbide, and austenite, which contains, of course, carbon and phosphorus in solid solution. Fig. 11 illustrates the characteristic appearance of this eutectic which solidifies between the primary dendrites of the metal. It appears when cold as a binary eutectic, but this is due to the fact that the carbide diffuses out of it after solidification. This eutectic solidifies at 950 deg. C., a temperature 180 deg. C. lower than that of the austenite-cementite eutectic mentioned earlier. Phosphoric irons are more fluid and have a longer freezing range than non-phosphoric irons. Both these qualities are beneficial, as they increase the possibility for the escape of suspended impurities, and also the gases from the metal when in the mould. Against these advantages there is, of course, the embrittling action of phosphorus to be considered. The eutectic is extremely hard; a fact that can be readily shown by giving a micro-specimen of phosphoric grey iron rather more polishing than usual and then examining under the microscope. The phosphide eutectic stands out above the softer matrix and can be recognised even before an etching reagent is applied; further, a needle will scratch the matrix but leaves the phosphide eutectic untouched.

Researches conducted by various workers have failed to reveal that phosphorus has any appreciable influence upon the rate of decomposition of the carbide in cast iron. A phosphoric grey iron

appears somewhat lighter in fracture than a similar non-phosphoric iron, but this is due to the presence of the brilliantly white phosphide in the eutectic. To sum up the influence of phosphorus, one may say that it produces an iron which can be handled more easily in the foundry than a hematite iron, its tensile strength may be greater, but its resistance to shock is diminished.

A review of the composition of foundry irons would not be complete without some reference to the influence of dissolved gases. An excellent summary of this subject is published in The Foundry Trade Journal of March 15, 1923. Carpenter and Rugan heated an iron containing T.C., 3.38; Si., 6.14; Mn., 0.3; S., 0.01; and P., 0.013 per cent. *in vacuo* at about 900 deg. C., and obtained gases of the following composition: CO, nil; CO_2, nil; O_2, nil; H_2, 87.5; and N_2, 12.5 per cent.

In this case the silicon is abnormally high and, as would be expected, any oxides of carbon absorbed by the metal during melting have been decomposed to form silica and carbon. A further sample containing 3.98 per cent. T.C. and 1.07 per cent. Si. yielded: CO, nil; CO_2, 1.09; O_2, nil; H_2, 98.54; and N_2, 0.37 per cent.

It appears from these figures that hydrogen forms the major portion of the gas occluded in solid cast iron. Fig. 12 gives the solubility curve for hydrogen in pure iron. A marked decrease in solubility occurs at the freezing point and is responsible for the formation of gas-holes. It is unfortunate that at the present time there is no

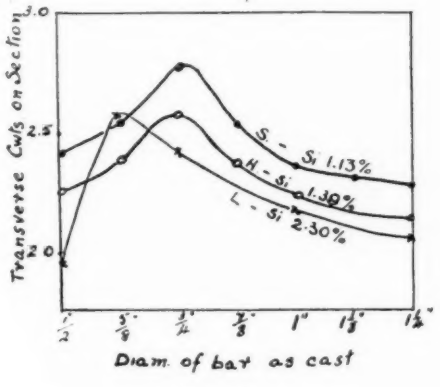

Fig. 13.

Curve showing the variation in transverse strength with diameter of bars as cast.

dependable data as to the effect of dissolved gases in cast iron (apart from gas-holes of course); they constitute an imponderable factor and may be responsible for some of the anomalies which are found to exist in practice.

The Influence of Rate of Cooling upon the Metallography and Physical Properties of Cast-iron.

So far the physical properties and microstructures of the ordinary grey foundry irons have not been considered. It has been pointed out that the naturally white irons (by naturally white irons is meant irons which have a microstructure similar to that shown by Fig. 6 and show a white fracture when cast into sections of normal thickness) are unsuitable for machine or structural parts owing to their brittleness and unmachinability. By increasing the silicon somewhat, however, an iron is obtained which is white in the "as cast" state, but which by subsequent annealing can be readily made to precipitate graphite. By this treatment one obtains a structure similar to that shown in Fig. 7; such an iron, which is commonly known as black-heart malleable, most nearly approaches in its properties to those of the steels. For ordinary foundry purposes, however, the grey structure is obtained directly by using higher silicon and total carbon contents. The main disadvantage of producing the grey structure directly is that flakes of primary graphite are formed instead of the nodular graphite found in malleable iron. As graphite has no mechanical properties, the positions occupied by it may be considered simply as cavities in the metal. If one subjects a flat test piece, through which a hole is pierced, to tensional stress, there is a localisation of stress at the edges of the hole which is expressed by the following formula:—

$$P = A\left(1. + \frac{2a}{b}\right)$$

Where A = average stress throughout the test piece · P = stress at edge of hole; A = diameter of hole at right angles to the direction of stress; and b = diameter of hole parallel with the direction of stress.

For a circular hole this means that the stress

Fig. 14.

L 1 Bar etched x 100. It contains Si 2.3 and CC 0.75 per cent.

at the edge is three times the average stress, and fracture will naturally begin from this point. This shows conclusively that even the more or less spherical nodules of graphite in malleable iron have a considerable weakening effect when the metal is subjected to tensional, transverse, or impact stresses. It will be seen from the formula that when the diameter "a" becomes very much greater than "b," as in the case of a hair-crack, the localised stress approaches infinity. Graphite flakes act more or less in the same way as a small crack, and their weakening effect will depend on their number,

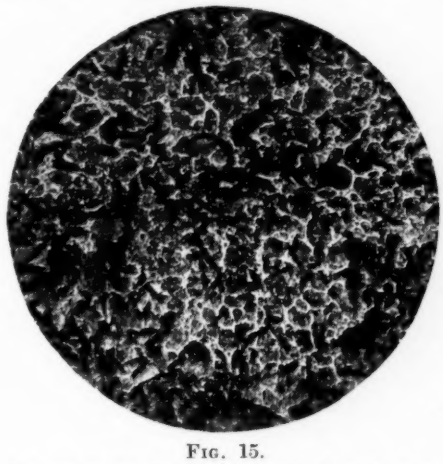

Fig. 15.

L 2 Bar (Si 2.3 and CC 0.67 per cent.), etched x 100.

distribution, and size. The fewer and shorter they are, or more modular, the greater will be the strength of the metal. Notwithstanding this, however, non-chilling irons are used for general foundry work, owing to their relative cheapness, machinability, and good casting properties, and it is proposed later to study some of these normally grey irons in relation to the influence of rate of cooling.

Fig. 12 shows at a 100 diams. the faintly mottled structure of an iron containing 3.56 per cent. T.C. and 1.39 per cent. Si., which was cast

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as a ¼-in. dia. bar in green sand. The structure consists of nests of primary graphite flakes in a matrix of finely dispersed pearlite and free cementite. The striated structure is due to the growth of chill crystals which radiate inwards towards the centre of the bar, and are analogous to those found in the outer zones of a steel ingot. When a metal is very rapidly cooled through the solidification range, crystallisation proceeds from innumerable centres within the liquid mass; when

Fig. 16.

L 5 bar (Si 2,3 and CC 0.65 per cent.) etched x 100.

slowly cooled, crystallisation commences from relatively few centres or nuclei. Therefore a rapidly-cooled metal has a fine structure as in this case, and a slowly cooled, a comparatively coarse structure as in the case of the white cast iron shown by Fig. 6 at the same magnification. Chilled metal such as shown in Fig. 12 is extremely hard and lacking in mechanical strength owing to the large amount of free cementite present.

In order to study more the influence of rate of cooling, and also to discover the microstructure which is typical of a grey iron in its strongest state, a number of round test bars were cast in green sand 14 in. long and varying in diameter from ½ in. (and in some cases less) up to 1¼ in. The bars were placed vertically all in one moulding box, and were top-poured from a central runner. In this manner a uniform composition was assured throughout the bars, the only variable being the rate of cooling as governed by the size of the section. Three different grades of metal were cast on this principle, and the casting temperatures were kept as far as possible constant, in order that the sets of test bars from each grade should be comparable. After casting, the bars were turned down and ground smooth to 0.5-in. dia. They were then broken in a Denison transverse testing machine between 12-in. centres. The fact that they were turned down to one size is important, as although the values obtained from round bars broken in transverse at different sizes may be calculated to a common section, say 1 sq. in., there are certain errors involved for which it is very difficult to make allowance. Analyses of each grade of metal were made, and drillings were also taken from each bar and analysed for the graphite content. These results are embodied in Table II, which also includes the diameters of the bars as cast, the transverse values, and the combined carbon (by difference) in each bar.

Fig. 13 is a curve plotted from the figures in Table II, and shows the variation of transverse strength with the different rates of cooling as governed by the original diameters of the bars. Micro-specimens were taken from the bars adjacent to the fracture, and in Figs. 14-22 are shown the structures of the smallest bar (½-in. dia.), the bar showing the maximum transverse strength and the largest bar 1¼-in. dia.) of each set. All these were lightly etched with 2 per cent. HNO_3 in alcohol and photographed at exactly 100 diameters. Fig. 14 is taken from the L.1 bar, which contains 0.75 per cent. combined carbon and 2.3 per cent. Si. The grain size is very small, the phosphide eutectic network is

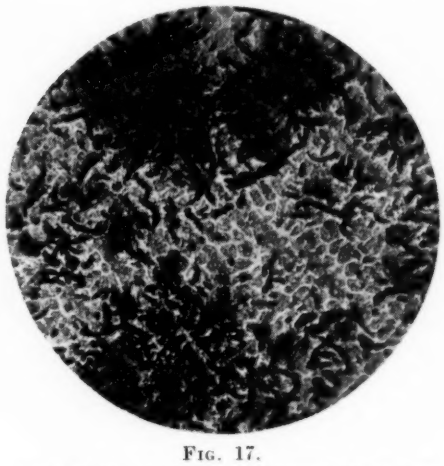

Fig. 17.

H.I. Bar (Si 1.39 and CC 0.89 per cent.), etched x 100.

broken up, and the graphite flakes slightly bunched. Fig. 15 shows the structure in the L.2 bar, which gave the highest transverse value in this series; it contains 0.67 per cent. combined carbon.

The structure is very slightly larger, but the phosphide forms a nearly continuous network and the graphite flakes are more evenly dispersed. Fig. 16 reveals the structure of the L.5 bar cast at 1¼-in. dia., which gave only 2.06 cwts. on the

Table II.—*Influence of Rate of Cooling on a Series of Grey Iron Bars.*

Mark.	T.C. per cent.	Si. per cent.	Mn. epr cent.	S. per cent.	P. per cent.	Dia. of bars as cast inches.	Trans. in cwts. on 5 in. bar.	Gr. per cent.	C.C. per cent. (by difference).
L. 1	3.38	2.30	0.51	0.08	1.00	½	1.94	2.63	0.75
L. 2						⅝	2.56	2.71	0.67
L. 3						¾	2.41	2.73	0.65
L. 4						1	2.19	2.73	0.65
L. 5						1¼	2.06	2.73	0.65
H. 1	3.56	1.39	0.55	0.11	0.86	½	2.25	2.67	0.89
H. 2						⅝	2.58	2.73	0.83
H. 4						¾	2.58	2.73	0.83
H. 4						¾	2.38	2.73	0.83
H. 5						1	2.25	2.76	0.80
H. 6						1¼	2.13	2.78	0.78
S. 1	3.54	1.13	0.53	0.115	1.00	½	2.41	2.28	1.26
S. 2						⅝	2.53	2.36	1.18
S. 3						¾	2.78	2.70	0.84
S. 4						¾	2.53	2.70	0.84
S. 5						1	2.35	2.72	0.82
S. 6						1⅛	2.33	2.75	0.79
S. 7						1¼	2.28	2.75	0.79

Note.—The first bar in each series (½ in. diameter), was cleaned up with emery paper and broken without machining.

0.5-in. dia. test piece. The structure is much larger and the phosphide is unevenly aggregated. It is remarkable that the matrix still consists entirely of pearlite, the combined carbon being 0.65 per cent. Figs. 17, 18 and 19 represent the appearance of the "H" series, containing 1.39 per cent. Si. The smallest bar (Fig. 17) shows an approach to the mottled structure, although to the naked eye the fracture appears quite grey. The strongest bar again shows an even distribution of phosphide and graphite (Fig. 18), and the 1¼-in. bar (Fig. 19) reveals the coarse and uneven phosphide structure and larger graphite flakes. Figs. 20, 21 and 22 are taken from the "S" series containing 1.13 per cent. Si. In Fig. 20 there are the first definite evidences of the preservation of free carbide. This bar was very much over-chilled and contained 1.26 per cent. combined carbon: both the uneven distribution of the constituents and large amount of free carbide present are sources of weakness. Fig. 21 gives the micro-structure of the strongest bar, and which once again shows an even and fine distribution of phosphide and graphite contained in an eutectoid matrix. Fig. 22 is taken from the largest bar in this series; the structure is coarser than the last, but otherwise is very similar. The combined carbon is 0.79 per cent.

That for each grade of metal there is a certain rate of cooling which gives the maximum strength is a fact that is quite well known. Curves very similar to those shown in Fig. 13 were obtained by P. A. Russell (THE FOUNDRY TRADE JOURNAL, September 27, 1923, page 276), but in this case

FIG. 18.

H 3 bar (Si 1.39 and CC 0.83 per cent.) etched x 100.

bars of rectangular cross-section were used; they were cast 13½-in. long by 1-in. wide, and varied in depth from ¾ in. up to 1¼ in. They were broken between 12-in. centres. Two grades of metal were tested, and in each case a decided "peak" in the curve was obtained.

The outline of the experiments previously described was suggested by a perusal of the above-mentioned Paper, only, in order to avoid the chilling which is liable to occur at the corners of square bars, it was decided to use round bars and cast them vertically; such bars also conform in general principle more nearly to those suggested in the "Tentative Specification for Castings in Grey Iron," issued by the Committee appointed by the Institute of British Foundrymen. The work put forward in the latter part of this Paper fully confirms the curves obtained by Mr. Russell, and carries the matter somewhat further by investigating the reasons for the changes in mechanical strength as evidenced by the microscopy of the metal under various rates of cooling.

The photo-micrographs which have been chosen as representing the gradual changes that occur in each series of bars show conclusively that the greatest transverse strength is obtained when the metal is cooled as rapidly as is possible without retaining free carbide in the structure. Under these conditions one obtains an even distribution of small graphite flakes and a nearly continuous network of phosphide eutectic in an all-pearlitic matrix. An iron cooled slightly too rapidly shows a distinct bunching of the graphite, which is really an approach to the mottled structure, even though this may be quite imperceptible to the naked eye and not revealed by the combined carbon content. On the other hand, an iron too slowly cooled has a much coarser structure both as regards the graphite flakes and the phosphide eutectic. In the H.6 bar the phosphide network exists in isolated patches, and in the S.6 bar the network itself has broken down. Cook and Hailstone found that specially strong bars of phos-

FIG. 19.

H 6 Bar (Si 1.39 and CC 0.78 per cent.), etched x 100.

phoric grey iron tested by themselves had in each case a nearly continuous phosphide eutectic network. It is difficult to believe that the presence of such a brittle compound as the phosphide eutectic can confer strength in itself, and the author is inclined to think that an even cellular distribution of the phosphide should merely be taken as an indication of the general homogeneity and the fine-grained nature of the structure. The size and number of the graphite flakes are undoubtedly of much greater importance.

That the whole of these bars should have an

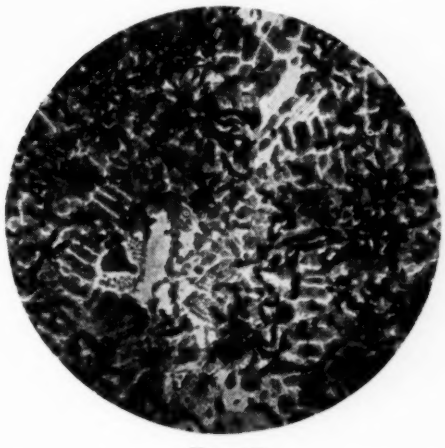

FIG. 20.

S.I. Bar (Si 1.13 and CC 1.26 per cent.), etched x 100.

all-pearlitic matrix, with the exception of S1., which contains free cementite, was rather unexpected. One would anticipate that the larger bars, particularly those containing 2.3 per cent. Si., would show evidences of breakdown of the pearlitic carbide. That this is not so is shown by the microstructure and also by the absence of any appreciable diminution of the combined carbon in the larger bars. The austenite in cooling down continuously throws carbide out of solution, which decomposes and precipitates graphite upon the primary flakes already formed. The rate of cooling in order to partially prevent this has to

be extremely rapid. When it is not prevented an all-pearlitic iron is produced in natural course. It appears probable that there is another critical but much slower rate of cooling at which the pearlitic carbide will decompose with comparative rapidity.

Fig. 23 shows a grey foundry iron which has formed the lip of the charging door of a cupola. This iron has been heated to redness and allowed to cool daily in the ordinary course of working for approximately five years. The final composition was graphite 2.51; C.C., nil; Si., 2.49; P., 1.00; Mn., 0.53; and S., 0.13, 13 per cent. This is

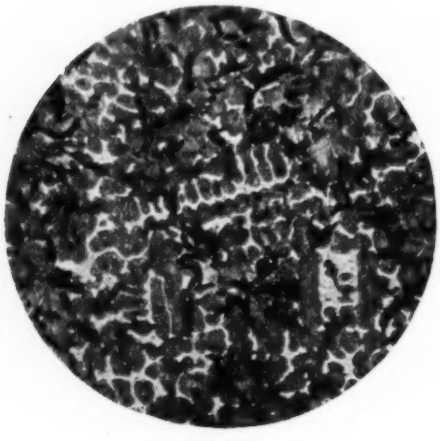

Fig. 21.

S 3 Bar (Si 1.13 and CC 0.84 per cent.) etched x 100.

an iron very similar to those used in these experiments, the low total carbon being due to oxidation. This, although produced by repeated annealings, represents equally well the structure which would be produced by excessively slow cooling, and consists of very large graphite flakes and phosphide eutectic in a matrix of ferrite.

An examination of the combined carbon contained in these bars lends confirmation to the statement often made that silicon decreases the amount of carbide contained in the pearlite. Thus in the iron containing 2.3 Si. and 0.65 per

Fig. 22.

S 7 Bar (Si 1.13 and CC 0.79 per cent.) etched x 100.

cent. combined carbon is sufficient to give an all-pearlitic matrix, whereas 0.83 per cent. is required in the iron containing only 1.39 per cent. Si. From this it follows that a determination of the combined carbon does not in itself serve as at all a delicate test as to whether an iron is in the best physical condition, unless one possess data from which to make satisfactory allowance for the silicon content.

It will be noticed in Fig. 13 that the lower the silicon in these irons the higher the transverse strength, notwithstanding the fact that the microstructures are almost identical. The graphite contents in the three series of bars are also very similar, so that the difference cannot be attributed to varying amounts of this weakening constituent. The outstanding differences lie in the silicon content, and the combined carbon required to form the pearlitic structure. The average combined carbon contained in the non-chilled bars is as follows: "L" Series, 0.655 per cent. C.C.; "H" Series, 0.81 per cent. C.C.; and "S" Series, 0.816 per cent. C.C.

It seems possible that the displacement of carbon from the pearlite may be responsible for some of the weakness shown by the higher silicon bars, but also it seems that the presence of silicon in solid solution is itself also to some extent responsible. As has already been pointed out, the addition of up to 5 per cent. of silicon to pure iron, which is very soft and ductile, increases the tensile strength. Beyond this amount the strength again falls off owing to the excessive brittleness of the alloys. Its addition in large amounts to cast iron, which at the best is rigid and brittle, is however quite another matter. Professor Turner ("The Metallurgy of Iron," page 252) has shown that with 2.0 per cent. T.C. and less than 0.4 per cent. P., the maximum tensile strength occurs at approximately 1.8 per cent. Si. and the maximum transverse at 1.4 per cent. Si. With 1.00 per cent. it appears from the results given in this Paper that the maximum occurs at a still lower percentage of silicon.

One other point may be mentioned in regard to Fig. 13. The maximum strength would be

Fig. 23.

Burnt Grey Foundry Iron (Gr 2.51; C.C. nil; Si 2.49; Mn 0.53 and S 0.13 per cent.

expected to occur at larger and larger sections as the silicon percentage is decreased. Series "L" and "H" show this expected difference, but the maximum for the "S" series occurs on the same section as the "H," although at a higher value. This anomaly is due in all probability to the slightly lower temperature at which the "S" bars were cast. The lower temperature would give an increase in the rate of cooling of every bar in the series and move the maximum towards the left on the curve (Fig. 13).

A consideration of the foregoing will make it evident that, from a practical point of view, the best results are likely to be attained by using the lowest possible silicon and total carbon contents that can be safely depended upon to give a non-chilling effect in the smallest important section of a casting.

In conclusion, the author would like to convey his appreciation to Messrs. Alfred Herbert, Limited, for the facilities they have so willingly afforded for the preparation of this Paper, and also to the Chief Metallurgist, Mr. H. K. Ogilvie, whose advice and kindly criticism have always been available.

Considerable damage was caused by an outbreak of fire at the Castlelaurie Works of the Falkirk Iron Company, Limited, a large building recently adapted for use as a core shop being gutted.

Dry Sand and Loam Moulding.*

By A. Sutcliffe, M.I.Brit.F.

Introduction.

It is acknowledged that art is the result of work, and depends upon the skill and mental capacity of man, without the aid of formulæ. Ironmoulding, perhaps, cannot be classed amongst the fine arts, but it certainly is not crude. It is an industrial art. Considering the problems that remain unsolved in the foundry, and the difficulties which are added each day through the rapid advance of the engineering industry, it is no exaggeration to say that the work of the foundryman calls for more self-reliance, keen foresight, skill and concentration of thought than those industries which are assumed to be of more importance.

The moulder has no definite method of counteracting the erratic behaviour of the metal with which he deals; it is only by practical experience and the judicious use of the materials at hand that he obtains the satisfactory results that are witnessed to-day. It would be impossible, at least from a commercial point of view, to make flasks or casings to accommodate the number of patterns which differ in their thickness, size and contour, so that when a moulder has given due regard to the appliances at hand and finds he is short to deliver a certain job his mental faculty is called upon to supply some method that will sustain the mould and metal whilst casting.

Doubtless a knowledge of the nature and properties of sand adds to the interest in foundry work. But though various facts have been deduced in the laboratory, the moulder is again without a positive formula to guide him in practical work; he is still left to his resources. He judges the qualities of the sand by his sense of touch, and adds certain materials and energy to get a desired effect. In consolidating the sand around and in a pattern he is called upon to give due regard to its fragility, firmness of the sand to resist heat and liquid pressure, without impairing the porosity that allows the gases to strike back to the vents.

It is proposed to outline a number of typical jobs recently made, which might have been produced by either the dry sand or loam method. This matter is treated from a jobbing-foundry point of view, and it is not claimed that these methods are in any way superior or even as good as might be possible if made in a foundry specially equipped for one class of work.

Green Sand Moulds.

As is well known, moulds that are made in various kinds of sand and retain their own moisture until poured or cast, are termed green sand moulds. This method is, without doubt, the best for making the majority of castings in ordinary foundries doing work in connection with modern engineering.

When moulding in green sand, sands that are charged with moisture above a certain limit should not be used, as any attempt to pour hot metal into a wet mould will immediately generate dangerously-large quantities of steam and gas, and the molten metal will not lie on the bottom or face of the mould, as these gases and steam, causing it to be blown or forced back through the runners and risers just after casting. A mould of this kind is useless, but it serves to show the danger of an excess of moisture in green sand.

No additional venting will ensure a sound casting in such circumstances, and even did the casting appear to be a success there would be trouble with machining and fitting, and the casting would not stand the strain sometimes demanded, being too hard and brittle. On the other hand, sand rather too dry will not bind, but will fall and crumble away; or if it did stand in the mould it would very likely be washed away from its position by the force of the metal passing from runner into the mould. It is evident, then, that combined sound judgment and experience are required to determine the amount of moisture to be used in the making of clean green-sand moulds, which will readily discharge the air and gases, and cause no trouble to the moulder or anyone concerned.

Skin-dried Sand Moulds.

Skin-dried moulds are those which are rammed up in green sand, and then dried skin deep, after being cleaned up and washed with wet blacking. It will be seen that by skin-drying a mould the moisture on the surface or face of the mould is reduced to some extent. Skin-dried moulds often give sounder and much cleaner castings than do green sand moulds, and when cast do not generate as much steam and gas, and are therefore less liable to give blown or scabbed and dirty castings. There are moulds which it is necessary to skin-dry owing to their intricate and delicate construction. Such moulds are better able to withstand the flow and force of the molten metal in passing down the runner and then over the face of the mould at the time of casting.

Reducing the moisture on the face and walls of a mould also stiffens the green-sand cores, and there is not the same likelihood of particles being washed up from the face and walls of the mould as with green-sand moulds.

Dry Sand Moulds.

Dry-sand moulds are those which are rammed up in the same way as the ordinary green-sand mould, but are subsequently dried. These moulds should be vented to a certain extent in exactly the same way as green sand moulds, for although there is no moisture to expel or force through the walls of the mould, there is always a certain amount of gas generated in the sand at the time of casting, which will pass and escape through the vents without any marked effect. When not vented, sometimes these moulds explode or their gases ignite before the pouring or casting is finished, and the shock causes the face or top of the mould to suffer by small pieces being shaken off, the result being a dirty and unsatisfactory casting, only fit, perhaps, for the scrap heap.

Loam Moulding.

There is little in common between sand and loam moulding, except that each method forms a mould that will hold molten iron and turn out a satisfactory casting.

A loam moulder's daily routine is concerned with spindle plates, bricks, straight-edges and square, strickling boards, strickles, etc., whilst the sand moulder is concerned with various kinds of patterns.

When making a casting in loam, whether large or small, plain or difficult, the preparation of the tackle is most important, and if the casting is a difficult or intricate one there is more reason for forethought by draughtsman, pattern maker and moulder at this point.

The work is laid out full size, as far as is necessary in the pattern shop, and the moulder, with the aid of the pattern maker, procures the dimensions for his tackle from it. The important points for the moulder to watch in this matter, apart from the correctness of size, is, first, that the tackle is sufficiently strong: second, that provision is made for runners and risers, bolting up, and escape of air; third, provision for easing or liberating after pouring, and for the contraction of the casting. It is far preferable for a moulder to err, within reason, on the heavy rather than on the light side when making his tackle, because the breaking or snapping of a plate, binder, staple or bolt often means commencing afresh, besides the possibility of injuries to those near the work.

Efficiency in Handling Bricks and Mud.

In arranging the work, the most efficient manner of bringing both bricks and mud to the wall will depend upon the size of the job, thickness of the wall, and whether the wall is being run up in a pit or above the floor level.

* A Paper read before the Burnley Section of the Institute of British Foundrymen.

At some shops, skips or buckets handled by the crane are used to deliver the bricks to the moulder. Where this is the case, the bricks should be carefully arranged in the skip in order and not thrown in haphazard. When the bricks are piled in the skip neatly the moulder makes the same motions in removing each succeeding brick, and does not have to twist his arm back and forth to grab bricks lying at various angles.

As the wall rises both the bricks and the mud should be delivered as nearly on the level of the wall as possible. In some cases the moulder's helper piles the bricks on to short "board packs" and places these on a box or pair of "horses" beside the moulder. The bucket of mud should also be set on a box or "horses" as near the level of the wall as possible.

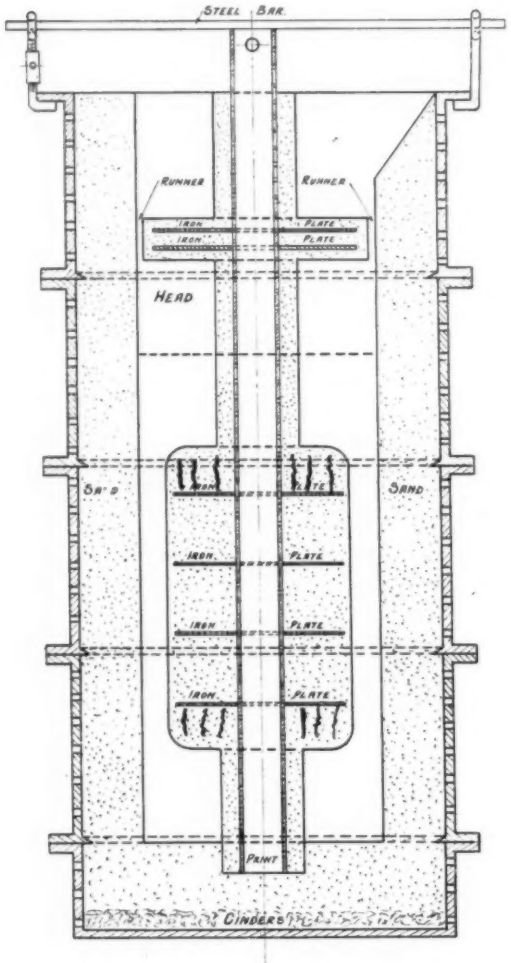

Fig. 1.—Mould for Ram Casting.

Increased Efficiency and Lessened Effort.

By carefully considering these items, and eliminating, so far as practicable, unnecessary and fatiguing work on the part of the moulder, the number of bricks he can lay in a day will be materially increased without adding to the physical effort he must put forth.

Good moulders intuitively recognise the advantage of proper handling of bricks and mud, and it is the thoughtful observance of these minor savings that differentiates between the high-grade loam moulder and the indifferent workman.

MOULDING A RAM CASTING.

The making of this casting in loam will first be dealt with. The author has seen similar castings made in many foundries in Lancashire and Yorkshire in both loam and dry sand.

For the loam method plates of different sizes are required: a bottom plate, cope-ring, two building rings, and, if the casting is over 6 ft. long, it will require splitting to enable the moulder to get it into the stove. This, of course, will cause more work, and will require another cope-ring and two extra building-rings, a top-plate with holes for risers and core, and two staples cast in for holding down the barrel core.

A start can now be made on the bottom plate with an inch seating, or a four-inch seating, for it is then merely a straight build all the way up, but two bricks must be left out at the bottom so that the moulder can remove the dropping loam from the strickle. An inch seating will be sufficient for the covering plate, as this will set the centre core.

If the coping has to be split in the centre it can be done on the building, or a dummy seating can be set up. If the mould is put together in the pit it will require ramming up.

It is assumed that all cores are made on a barrel, as shown in Fig. 1, but should they be made in the mould by the loam-moulder extra work is entailed, and the job will cost much more per cwt.

Another method of making a ram casting is by using half-boxes. It involves fixing the board fast to a horizontal spindle, revolving in a socket at each end of the box. This should be cored with a barrel core, put together and turned up on its end

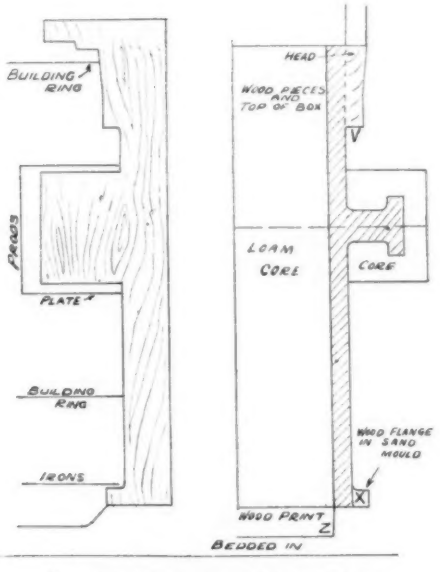

Fig. 2.—Cylinder for Crank Lathe.

to cast in a pit. Rams are also made in half-boxes in dry sand from a pipe pattern, cored and turned on end the same way as above.

This casting can also be made in boxes of two sizes—8 ft. inside, and 3 ft. 6 in. inside—with 18 in. deep middles and an 8-in. bottom, with shell patterns to form the outside part of the mould, as shown in Fig. 1. It will be seen that the bottom box is a full part, having no bars. It has only two 3-in. holes in the bottom, and is perforated on the sides.

The method adopted by the author is to put some cinders in the bottom box, and ram up with sand to the joint. At this point the shell pattern is placed in position, putting eight sprigs on the outside of pattern, so that the moulder can get the centre for the print. Then each middle is rammed up, making a joint at each box, or every two. The middle boxes have a flange all round on the bottom inside to prevent them from dropping out after being in the stove for the night.

After having rammed up to the height required sufficient space is allowed for the runner, as shown in Fig. 1, scraped down at one side about a foot. The outside of the mould must be made higher, for, as will be seen, the core forms the casting.

How the Core is Made.

The core is made on a perforated iron tube or core barrel in the ordinary way, only a stop-piece 4 in. wide is incorporated to form the git, and this forms the end of the casting. This part of the core is ⅛th in. less than the body of the mould, and this will run a job weighing 5 tons.

A print is bedded in the bottom box. After the job has been in the stove over-night it is put together in the pit with three bricks on the bottom joint, so that when the core is lowered down the mould the moulder will be able to guide it into the print.

The bricks must be taken out after this has been done, and the middle boxes lowered into the bottom. After this the proceeding is to cotter up the whole and put three thin wedges between the core and the mould. The core will be in the centre of the mould; it is then bolted down as shown in Fig. 1, and is then ready for the metal.

After the cast, loosen the screw bolt which is holding the core down a little at a time, or the barrel will sag in the middle. It will be seen therefore that the dry sand method of making this casting is much quicker and cheaper than the loam method.

Cylinders for Crank Lathes.

The conditions appertaining to these were that an order was placed for six castings, which were made in loam, and a further order came in twelve months later for two similar castings. This time, as there were only two required, and all the loam plates had been broken up, to save expense it was decided to make them in the boxes used for the ram casting and in dry sand, especially as there was a shell pattern handy to form the outside of the casting.

So all that was required now was a flange for the bottom (X, Fig. 2) and a wood strickle for setting the cores in the centre, using the same core box as in loam. Then there must be provided some wood strips to form the top flange and head of the casting, also a blank flange from stock to set the core in the bottom.

It will be seen that this casting cannot be run the same way as a ram, as the metal would drop on the shoulder V, which would be wrong, so a covering plate is made with holes for the core to come through, and gits. This plate is held down with three clamps under the flange on the box, the barrel core being held in the same way as in the ram mould. After making up the git bush on the plate, it is ready for casting.

This mould being put together in the pit, it is better to cast with the ladle. The time for making this job in loam was 40 hours, whereas making the same casting in dry sand was 16 hours, including both moulding and core-making. The sand used for both this job and the ram was made up with 12 parts of red sand, 5 parts of black sand, 2 parts of sea sand, 3 parts of manure, and ¾ of a part of coal dust. It was milled for a quarter of an hour when all in the mill. The metal used was made up of 10 cwts. of steel, 20 cwts. of hematite, 20 cwts. of Scotch, 10 cwts. of Sheepbridge, and 40 cwts. of scrap. The casting analysed out at C, 3.0; Si, 1.3; Mn, 0.6; P, 0.4; and S., 0.1 per cent.

(To be continued.)

Institute of British Foundrymen.

Newcastle Branch—Junior Section.

The Junior Section held its last meeting of the session in the Neville Hall, Newcastle, on April 5, under the chairmanship of Mr. H. F. Clements (President). An interesting Paper, entitled, "The Cupola Furnace," was read by Mr. C. R. Van der Ben.

In summarising his Paper, the lecturer said that melting in a cupola was quite as much an art as melting in an open-hearth furnace, the difference being that, whilst much data has been gathered in the case of the open-hearth furnace, much remains to be done in cupola practice.

The cupola is one of the most important factors in foundry practice, and commands the attention of the founder to a far greater extent to-day than it has ever done in the past. No matter how much attention is lavished upon the mould, it is impossible to produce a first-class casting unless the metal is up to that standard which the proper use of the cupola furnace warrants.

Fluxes and Slags in Metal Melting and Working.

A general discussion is to be held by the Faraday Society and the Institute of Metals, with the co-operation of the Institute of British Foundrymen and the British Non-Ferrous Metals Research Association, at the Institution of Mechanical Engineers, on Monday, April 28, from 3 p.m. to 7 p.m.

The following programme of Papers will be submitted:—

PART I.—3 to 4.30 p.m.

Chairman: PROFESSOR T. TURNER, President of the Institute of Metals.

General Introduction.—PROF. C. H. DESCH, F.R.S.

"Oxidising Fluxes in the Melting of Non-Ferrous Metals," by A. PORTEVIN.

"On the Origin, Properties and Influence of Slags in Brass Melting," by DR. H. MOORE and R. GENDERS.

"Note on Slags from Lead, Copper and other Blast Furnaces," by G. RIGG.

"Slags in Relation to Copper and Brass," by DR. A. SCOTT.

"Slags produced in Melting Silver Alloys," by J. PHELPS.

"Sulphurising and De-sulphurising of Metals by Fluxes and Basic Slags," by R. BOGITCH.

General Discussion.

PART II.—5 to 7 p.m.

Chairman: SIR ROBERT ROBERTSON, K.B.E., F.R.S., President of the Faraday Society.

"Slag Inclusions in Relation to Fatigue," by PROFESSOR B. P. HAIGH.

"Fluxing Problems in Welding or Mild Steel with the Metallic Arc," by H. OGDEN.

"Fluxes and Slags in Oxy-Acetylene Welding," by C. COULSON-SMITH.

"Fluxes and Slags in Welding," by W. SPRARAGEN.

"The Use of Fluxes in the Melting of Aluminium and its Alloys," by DR. W. ROSENHAIN and L. ARCHBUTT.

"Note on Non-Metallic Inclusions in Metals, with Special Reference to Aluminium," by A. G. LOBLEY.

"Fluxes Used in the Tinplate Industry," by DR. G. T. BAILEY.

"Fluxes in Soft Soldering," by T. B. CROW.

Advance proofs of most of the above Papers will be available before the meeting; application for these to be made to the Secretary of the Faraday Society, 10, Essex Street, London, W.C.2. Non-members of the above Societies are asked to enclose 3s. 6d. to cover cost.

Production of Pig-iron in March.

The production of pig-iron in March amounted to 668,600 tons, compared with 612,700 tons in February and 633,600 tons in March, 1923.

The number of furnaces in blast at the end of March was 194, a net decrease of 8 compared with February.

The production includes 214,800 tons of hematite, 235,100 tons of basic, 150,200 tons of foundry and 36,500 tons of forge pig-iron.

The output of steel ingots and castings in March amounted to 825,200 tons, compared with 767,600 tons in February and 802,500 tons in March, 1923.

The Advertiser's A B C. Published by Messrs. T. B. Browne, Limited, 163, Queen Victoria Street, London, E.C.4. This is a useful directory for any firm having to commence or extend large publicity programme, as every British periodical is described. Its usefulness could be increased for technical advertisers by the incorporation of lists of foreign and colonial technical journals.

Making Lead-lined Pipe.*

The most widespread application of the combination of lead and steel in this way is, of course, the manufacture of lead-lined iron pipe. This product has been used for decades in competition with homogeneous pipes of lead, iron and brass for use with liquids of slight corrosive action, and in recent years it has become a very important part of the equipment of plants in the chemical industries for handling acids and similar destructive liquids.

The lining of iron pipe with lead is done by two different methods, and it is essential that the buyer of the pipe understand them if he would obtain satisfactory results from their use. The first and cheaper method produces a cast lead lining, while the second provides a more dense lining of extruded lead tubing. The cast lead lining is, of course, economical, and should be used where the corrosive agent is a comparatively feeble one—impure water, for instance. The second method results in what is called a "tube-lined" pipe, and the lead contains none of the impurities that are always to be found in cast lead, and furthermore, it is not porous in the slightest degree. Where strong acids or other corrosive chemicals are to be conducted, it pays to use this tube-lined pipe in spite of its higher cost, for these liquids seldom fail to take advantage of the presence of the smallest particle of impurity that may result in electrolytic action, starting a local corrosion that will soon progress through the wall of the pipe.

The Lining Process.

The manufacture of the cast-lined pipe is an ingenious process. The iron pipe is first pickled and galvanised, for lead will not alloy directly with iron, but will combine very effectively with a zinc go-between. The combining of the metals in this way is responsible for the name "amalgamated," often used for this type of pipe. The galvanised pipe is now taken to the lining machine, where it is laid along the lower part of the trough or ramp which is at about 30 deg. with the horizontal and twice as long as the pipe. Here it is clamped at its lower end in a vise that can be run up and down the slope, carrying the pipe with it. From the top of the incline a narrow feed pipe extends downward along the sloping runway. In the wall of this pipe near its lower end there is a hole, and projecting from the end is a long plug or mandrel of the same diameter as the opening that is desired in the finished lead-lined pipe. The pipe to be lined is now pushed up the ramp. It meets the end of the feed pipe and runs on over it, sheathing it. A ladleful of the molten lead is now poured into the top end of the feed pipe, and when this begins to run out of the lower end of the pipes a circle of streams of water is played upon the outside of the iron pipe from the quenching ring, which is concentric with the mandrel at the end of the feed pipe and which is now also directly over the outside of the iron pipe at its lower end. The lead solidifies at once at this point, and prevents more lead from escaping. The hot lead that is poured into the feed pipe now runs also into the annular space between the two pipes, where it is kept fluid by a series of gas burners distributed along the length of the pipe. And now, with the streams of water again playing on the pipe over the mandrel, the iron pipe is drawn slowly down the ramp. The space between the mandrel and the pipe is kept filled with hot lead from above, and this solidifies in place as the pipe passes over the mandrel and through the quenching ring, leaving the pipe with a lead lining of accurate thickness. The centreing of the feed pipe in the pipe being lined is provided for by the presence of small longitudinal lugs on the former.

As the starting and stopping of this process would otherwise leave irregularities in the lining, necessitating the cutting off of several inches of the pipe at each end, false ends about 8 in. long are generally screwed on to the pipe to be lined and taken off after the lining has been laid in.

Making Tube-lined Pipe.

The manufacture of tube-lined pipe is a simple but comparatively slow and expensive process. While a lead tube can be used loosely inside an iron pipe, in most cases this is very unsatisfactory, for buckling is likely to take place, resulting in disastrous leakage. So in most cases where actively corrosive liquid is to be conducted safely, discretion demands the so-called tube-lined pipe. This is made by expanding a lead tube into the iron pipe and sweating or soldering the two together.

The machine that does this consists principally of a long spindle, at the end of which is an "expander." The lead tube and the iron pipe both having been tinned, the one is slid into the other and the whole placed on a support so arranged that the "expander" can enter the end of the double pipe. The pipe is heated from the outside while the "expander" is revolving, and progressing through the length of the pipe, expands the lead tube tightly against the inside of the iron pipe, where the temperature and pressure cause the metals to unite.

* Extracted from "Chemical and Metallurgical Engineering."

Foundry Queries.

Heat Resisting Irons.

Can you please inform us of the best mixture for cast iron to withstand heat and suitable for fire bars and other castings for generating stations?—"Growth."

Coke Consumption and Lining Thickness.

Our foundry has an output of about 3 tons per week of small castings, the heaviest being about 14 lbs.

We cast each day. What ought to be the weight of coke used, and what would be the best size for the inside of cupola? It is a wrought iron case about 30 in. external diameter.—T. M. G.

Cupola Tuyeres.

"B. F.," in his inquiry as to suitable tuyeres for 30-in dia. cupola, does not give sufficient details of his working to enable much assistance to be offered. It is, however, assumed that the diameter stated is inside the lining. The number of his tuyeres and their size are too small. The effect of so small tuyeres is so local that the tendency to oxidation of the metal dripping past the tuyeres may become very serious, small tuyeres always tend to oxidise the metal, because of the "non-spreading" character of the blast. It should be remembered that the objects to be aimed at are to supply air in such a manner as to secure complete combustion and to prevent bridging of the cupola.

A cupola should melt about 10 lbs. of iron an hour for every inch of horizontal area at the tuyeres. It is therefore a simple calculation to find out how much air should be delivered into any size cupola in a given time. "B. F." should melt in his 30-in. cupola about 3 tons per hour. The number of tuyeres he requires is 4, with an area each of 35 sq. ins. The air velocity through the tuyeres should be 25 to 30 ft. per second, and blast pressure 8 to 10 ozs. per sq. in. The pressure of his air blast is, of course, governed by the volume of air and the size of the tuyeres. Small tuyeres and large volume in the wind-box give high pressure.

Better working conditions will be obtained by flaring the tuyeres out at the cupola bore to twice the area of the entering ends, indeed the nearer the approach to the continuous type that can be obtained the better melting conditions will result.

If "B. F." will send us further details as to his difficulties, together with full particulars of his cupola working, we will advise further.—"Disce-Dosce."

Patent Specifications.

Particulars of Complete Specifications Accepted, furnished by Mr. Eric Potter, Patent Agent, of 27, Chancery Lane, London, W.C.2. Printed copies of the specifications in the following list are now on sale.

No. 206,120. Metal and Thermit Corporation. Sealing the jointed surfaces of sand and like moulds.

Trade Talk.

The Dome Electric Company have removed from 292 to 150, Stretford Road, Manchester.

Negotiations are proceeding for the re-opening of the spelter works at Skewen, which have been closed since 1918.

Hargreaves & Redfern, metal merchants, 19, Old Millgate, Manchester, have established warehouses at 311-3, Leeds Road, Bradford.

Clayton Wagons, Limited, have secured an order from the London & North Eastern Railway for 60 bogey carriages for the main line.

A fire broke out in the warehouse of J. & W. B. Smith, Limited, 21 and 23, Farringdon Street, London, E.C.1, which was destroyed. The damage was heavy.

At a meeting of the Sheffield Metallurgical Association, at which Dr. Rogers presided, Mr. C. H. Ridsdale introduced a discussion on "Tolerances in Analysis."

Wallace (Glasgow), Limited, makers of Glasgow single sleeve valve engines and pump sets, have established a branch at 6, White Street, Moorgate, London, E.C.

Vickers & International Combustion Engineering, Limited, have removed from 4, Central Buildings, Westminster, to Africa House (Fifth Floor, Kingsway, W.C.2.

A fire broke out on the premises of Rowland Hodges, brassfounders, of 165, Brearley Street, Birmingham, last week. The tool, polishing and stamping shops were gutted.

An outbreak of fire occurred at the Furness Shipbuilding Company's shipyard at Haverton Hill, but the flames were extinguished before damage of any consequence was done.

Blakeways, Limited, import and export engineers, of P. & O. House, 14-15, Cockspur Street, London, S.W.1, have been appointed agents for L'Industrie Metallurgique Sarre et Lorraine, nut and bolt manufacturers, of Sarrelouis.

William Allan & Company have appointed W. C. Yuille & Company, Limited, of 48, York Street and 15, Gordon Street, Glasgow, sole agents in Scotland for the "Nalla" adaptors.

W. Roderick John & Company, Limited, iron, steel and machinery merchants and exporters, have removed from 1, Exchange Buildings, Station Road, to Commercial Buildings, Port Talbot.

Soag Machine Tools, Limited, have removed their registered office from 18, Imperial Buildings, Ludgate Circus, E.C.4, to their showrooms and general office at 45, Horseferry Road, Westminster, London, S.W.1.

L. G. Hawkins & Company, Limited, industrial engineers, of 116, Charing Cross Road, London, W.C.2, have removed their Scottish branch from 141, Bath Street, to 97, Douglas Street, St. Vincent Street, Glasgow.

In the Chancery Division, Mr. Justice Eve has confirmed a petition by Sir James Laing & Sons, Limited, shipbuilders, of Deptford, Sunderland, for the reduction of the company's capital from £600,000 to £391,021.

A confidential report of a brief nature has been received from His Majesty's Consul at Stockholm relative to the market in Sweden for zinc sheets and ingots, and is in the hands of the Department of Overseas Trade

A paper on "Production" was read before the Birmingham Association of Mechanical Engineers, at their monthly meeting, by Mr. John A. Hannay (Austin Motor Company). Mr. W. E. Judge (president) occupied the chair.

The British Reinforced Concrete Engineering Company, Limited, of Manchester, have again secured the Leeds City Tramways yearly contract for the supply of B.R.C. fabric for tramway track foundations for the ensuing twelve months.

The newly registered company of Govan Engine Works, Limited, 180, Hope Street, Glasgow, have acquired the works at Princes Street, Govan, of Dunsmuir & Jackson, Limited. The plant and buildings are to be sold by private treaty.

The Newport Corporation have accepted the tender of Sir William Arrol & Company, Limited, for building a new bridge across the River Usk at Newport for £140,275. The bridge is to have five arches with steel girders, and the work is to be completed in 24 months.

Scotts' Shipbuilding & Engineering Company, Limited, Cartsdyke, Greenock, have an order from Alfred Holt & Company, of Liverpool, for a second twin-screw motor ship, 425 ft. in length. The vessel will be fitted with eight-cylinder single-acting engines of the Burmeister and Wain type, each developing 2,400 i.h.p., at 125 r.p.m.

Licences under the Non-Ferrous Metal Industry Act, 1918, have been granted by the Board of Trade to Hillis Bros. & Company, Limited, 37, Walbrook, London, E.C.4; Laband, Curt, 27, Queen Victoria Street, London, E.C.4; Mariner, William John, 98, Crawley Road, Luton; and Alexander & Alexander, 88/90, Chancery Lane, London, W.C.2.

In March 4 vessels of 9,013 total gross tons were launched on the Tyne, as against 5 vessels and 10,114 tons in the corresponding month last year. In the first three months of this year 17 vessels of 67,022 total gross tons were put into the water as compared with 13 vessels and 44,075 tons in the corresponding quarter last year, an increase of 4 vessels and 22,947 tons.

A large locomotive, the most powerful to be used on any railway in Great Britain, has been ordered by the L. & N.E. Railway Company for construction by Beyer, Peacock & Company, Limited, of Manchester. The new engine, which will have a total length of 80 ft., and a weight in working order of 165 tons, will be of the type incorporating two engines with one boiler.

Mr. Dickie, national organiser for the Association of Engineering and Shipbuilding Draughtsmen, spoke at a meeting of the Chesterfield Branch last week. As the outcome of the meeting it is hoped to revivify the branch, and the new officials include Mr. A. Clark (Plowright Bros.) as president; Mr. Shutt (Markham & Company) as vice-president; and Mr. E. S. Taylor as secretary.

The South Durham Steel & Iron Company, Limited, of Stockton-on-Tees, announce that on April 28 their registered and head office will be transferred to Mainsforth Terrace, West Hartlepool. Advice notes on behalf of the company's Malleable Works at Stockton-on-Tees should be sent there, and advice notes for the West Hartlepool works to Mainsforth Terrace, West Hartlepool.

Watson, Saville & Company, Limited, Bruce Crucible Steel Works, Mowbray Street, Sheffield, state that the agency agreement with Mr. J. F. Melling has expired, and it has been decided that it shall not be renewed. Mr. J. F. Melling, however, remains a director of the company, who have arranged with Bernard Holland & Company, 17, Victoria Street, Westminster, S.W.1, to take over the agency. Mr. B. A. Holland has been elected a director of the company.

Owing to the shortage of available liquid resources, Industrial Steels, Limited, Sheffield, are unable to carry on business pending other financial arrangements. In consequence the debenture holders have appointed Mr. H. Edgar Jenkinson, of Sheffield, as receiver. Sir H. Dennis Readett-Bayley, the chairman, in a circular announcing this, adds that steps are now being taken to prepare a scheme for reconstruction. The company was registered two years ago with an authorised capital of £700,000, to take over part of the works of Jonas & Colver, Limited.

The decreased demand for refined copper and iron-ore briquettes continues, and the production at the Hebburn works of the Bede Metal and Chemical Company, Limited, during the past year was far below their normal capacity, it being necessary to restrict the output to meet the reduced requirements. The improvements to the works have enabled the company to produce its various manufactures at much less cost than during recent years. Operations at the company's mine in Norway, which had practically been suspended for the past three years, have now been partially resumed.

The Council of the Federation of British Industries have addressed a communication to the President of the Board of Trade on the subject of the Anglo-German Mixed Arbitral Tribunal. The letter draws official attention to the very great delays which are being experienced by British claimants in getting their cases heard by the Tribunal. In this connection it is pointed out that a number of the claims lie under Article 296 of the Treaty of Versailles and concern debts, but that far the greater number deal with questions of compensation to British Nationals under Article 297 of the Treaty.

In the course of a lecture to the Falkirk and District Section of the Institute of British Foundrymen on the subject of "The Conveyance of Metal and Other Material in the Foundry," Mr. J. M. Primrose described the system of overhead runways by which was secured the easy conveyance of molten metal from the furnaces to the moulder. That system also ensured the safe and speedy conveyance throughout the foundry of moulding boxes and sand, and was used for the transference of castings from the moulding shop to the dressing shop, and thence to the warehouse and loading bank. The trollies of the bogies were equipped with ball bearings so that the heavy loads were transferred from one part to another with the minimum amount of manual labour.

Ashworth, Son & Company, Limited, of Newport and Dewsbury, are constructing for the Tredegar Iron & Coal Company, Limited, a railway weighbridge 54 ft. long, with a load carrying capacity of 180 tons, which will be the largest weighbridge of its kind in South Wales, or for that matter in the British Isles. The weighbridge comprises three 18 ft. units without intermediate dead space, which by the slight manipulation of a lever it is possible to weigh on each separate unit independently or on the three units in combination, whilst maintaining perfect equilibrium. In addition the weighbridge is fitted throughout with oil baths to entirely eliminate corrosion and wear to the working parts, and is considered to be the greatest achievement in modern weighing machine construction.

In connection with the opening of a handsomely-appointed canteen for the workers of Falkirk Iron Company opportunity was taken by several speakers to enlarge upon the aims and objects of the welfare movement, in which the Falkirk firm have played a leading part. Among those present were representatives of the Scottish Industrial Welfare Supervisors' Society, headed by Mr. Robert R. Hyde, London, Director of the Industrial Welfare Society. In the course of an address Mr. Hyde said there were in this country very many people who were constantly condemning the present system under which industry was conducted, so much so that they would even go the length of overthrowing it, but as a matter of fact that system had never been fully tried. He could not help feeling that many of the problems and misunderstandings which troubled them to-day would be removed by a readjustment of management. Management in the future was going to depend on leadership.

The Whitehaven Assessment Committee, in their annual report, stated that the rateable value of the Union at the date of last year's report was £351,057. It was now £344,681. The rating of the iron ore mines last year occasioned a great deal of difficulty, and it was finally agreed that the assessment of each mine should be based on the mine's output for the previous calendar year—the rate to be 2s. 5¼d. per ton—but that 25 per cent. should be added to the output in each case in view of the fact that during the previous year the output of the mines had been abnormally low. The Committee on the present occasion proposed that the arrangement should continue for a further 12 months, but that the actual output during 1923 should be accepted for the purpose without any arbitrary addition. The mine owners had agreed, and the effect of the arrangement had been to leave the assessment of the iron ore mines practically unchanged

On the occasion of his visit to Sheffield in connection with the work of the Industrial Welfare Society, the Duke of York visited the Rutland Works of Samuel Osborn & Company, Limited. Presentations took place in the entrance yard of directors of the firm in Mr. W. F. Osborn, Mr. Fred M. Osborn, Mr. A. Stanley Pye-Smith, and Mr. Eric C. Osborn, and also members of the staff in Messrs. Ian Osborn, J. E. Breakey, F. A. Hurst, J. R. Walker, H. Bradley, and E. Waterfall. The Duke inspected the Roll of Honour to the firm's war memorial, a similar memorial being at each of Messrs. Osborn's other works in honour of the 543 men who joined the Colours and of the 63 who gave their lives for King and country. He saw springs being made for the Buenos Aires Great Southern Railway, and for the Avonside Engine Company, Limited; carriage bearing springs for the Great Indian Peninsula Railway; tramcar springs for the Brush Electrical Engineering Company, Limited; locomotive springs for the London & North-Eastern Railway Company; and motor bus standard wagon bearings.

Contracts Open.

Bangkok, July 1.—Steel rails and fishplates, for the Siam State Railways. Mr. C. P. Sandberg, 40, Grosvenor Gardens, London, S.W.1. (Fee, £1 10s., non-returnable.)

Blackpool.—23,000 tons of 27-in. and 25-in. cast-iron socket and spigot pipes, and about 260 tons of socket and spigot and flanged specials, for the Fylde Water Board. Mr. J. Cook, engineer, Sefton Street, Blackpool.

Cardiff, April 26.—Cast-iron socket pipes (British standard) and special castings, for the Corporation. Mr. C. H. Priestley, waterworks engineer, City Hall, Cardiff.

Dewsbury, May 12.—Mild steel reinforcing bars (approximately 35 tons) for use in the construction of a ferro-concrete tank, for the Corporation. The Borough Engineer's Office, Town Hall, Dewsbury.

London, S.W., May 2.—(1) Rolled steel disc wheels and axles for carriages and wagons and steel axles for wagons; (2) steel tyres for carriages and wagons; (3) steel drawbars for wagons, for the South Indian Railway Company, Limited, 91, Petty France, Westminster, S.W.1. (Fee, 10s., non-returnable.)

London, W., April 29.—163 tons of steel girders and other iron and steel work of British manufacture, for the Great Western Railway Company. The Engineer, Paddington Station.

Riga, April 28-30.—102 and 66 metric tons of iron bars, for the Latvian Ra ilway Administration. The Departments of Overseas Trade.

Warminster.—1,000 yards of 8-in. cast-iron pipes, tested to 600-ft. head, valves and specials, for the U.D.C. Mr. C. H. Lawton, surveyor, Council Offices, Warminster.

Warrington, April 29.—Steam pipes and water pipes, for the Electricity and Tramways Committee. Mr. F. V. L. Mathias, borough electrical and tramways engineer, Howley, Warrington. (Fee, £1 1s., returnable.

Gazette.

A receiving order has been made in connection with the affairs of Mr. A. S. John, 1, Vaughan Street, Llanelly, and the Links, Pembrey, metal merchant.

The London Foundry Company, Limited, are being wound up voluntarily, with Mr. W. T. Walker, 53, New Broad Street, London, E.C.2, as liquidator.

The last day for receiving proofs in connection with a dividend to be paid by Mr. R. S. Mace, trading as Mace Bros., formerly carrying on business at 8, Washington Street, Birmingham, general brassfounder, is April 26.

The public examination of Mr. S. Burridge, 4, Chelsea Road, Sheffield, steel merchant, lately carrying on business at 21, Change Alley, Sheffield, has been fixed for May 1, at the County Court Hall, Bank Street, Sheffield. Liabilities amounting to £4,973, and no assets, are shown by the statement of affairs of Mr. Burridge. "Slump in trade, losses on contracts, and bad debts" are given as the causes of the failure. In October, 1919, without any previous experience or capital, he commenced business on his own account as an iron and steel and metal merchant at 39, Bank Street, Sheffield. Later he removed to 21, Change Alley, Sheffield. The business consisted practically in dealing with scrap. At the time of the coal strike, 1921, he had entered into a number of contracts to purchase materials, one being for £4,000 for the supply of steel girders, and another for £1,500. He was unable to obtain supplies, and in consequence of this his customers cancelled their orders. He could not obtain release from his contracts to purchase, and before he could find a market for his purchase prices began to fall, which resulted in considerable losses to him. The debtor also states that he made several bad debts.

Obituary.

Mr. W. H. Smith, a director of Thomas Smith & Sons of Saltley, Limited, died recently.

Lieut.-Commander P. W. Richards, the Sheffield secretary of the Federation of British Industries, died suddenly recently.

Mr. C. M. Taylor, formerly of Taylor & Bodley, Northam's Foundry, Commercial Road, Exeter, died recently in his 93rd year.

Mr. A. E. Boardman, managing director of E. Forshaw & Son, Limited, engineers and boiler makers, of Warrington, died recently.

Mr. F. J. Cribb, chief engineer with the firm of Marshall, Sons & Company, Limited, Britannia Ironworks, Gainsborough, has died at his residence, Sand Rock House, Retford, at the age of 71 years.

Mr. Arthur William Hutton, formerly managing director of the firm of John Russell & Company, Limited, tube manufacturers, of Wednesbury, and president of the Walsall Chamber of Commerce, died recently, at his residence at Clevedon, Somerset.

Mr. H. Russell, brassfounder, died at his residence, Duntanlich, Falkirk, recently. Mr. Russell, who was in his sixty-ninth year, was a native of Falkirk, where over 40 years ago he began business on his own account as a brassfounder, more particularly for the supply of goods required in the local foundry trade. With the development of the business he established a wider connection with the Scottish foundry trade generally and in England and elsewhere.

The "VULCANIA" PATENT WHEEL MOULDING MACHINE.

Patent No. 5049.

THE "VULCANIA" PATENT WHEEL MOULDING MACHINE is for moulding spur wheels with straight, sloping or Vee-shaped teeth, also bevel wheels, skew gear wheels, worm wheels and internal wheels. The machine head is carried on a pillar which is held in a base-plate bedded in the floor sand, and is made to slide on the pillar by means of a lever and link carried on a joint bearing, or by rack and pinion, or screw if thought advisable for the particular work it is being used for.

An adjustable stop collar is provided for accurately deciding the depth of mould. On the removable head a slide is carried for supporting the patterns of the teeth to be moulded. This slide is made adjustable by screw or pinion gearing to the diameter required. The number of teeth to be moulded is decided by a special dividing plate into which a steel wedge or finger engages. The special dividing plate has milled vees, at the angle of 60° inclusive, around its circumference, to receive the steel wedge, which is adjusted by a screw having an internal spring to keep it in tension and to lock the head when ramming operations are being carried out.

JAMES EVANS & CO., BRITANNIA WORKS (MANCHESTER), LIMITED.

BLACKFRIARS, MANCHESTER.

Company News.

National Electric Construction Company, Limited.—Dividend, 8 per cent. per annum.

Bede Metal and Chemical Company, Limited.—Loss, £1,093; debit balance brought forward, £29,932; debit of profit and loss account, £31,025.

Heat Treatments, Limited, 46, Bayswater Road, Handsworth, Birmingham.—Capital £2,000. Directors: J. T. Walton, J. Wallace and W. Gunston.

H. Wilson & Company (Engineers), Limited, Bank House, 28, Stratford Broadway, London, E.15.—Capital £500. Permanent directors: R. F. Frazer and H. Wilson.

Day Foundry & Engine Company, Limited, 2, Princes Road, Richmond, Surrey.—Capital £13,000 in £1 shares (10,000 6 per cent. participating preference and 3,000 ordinary).

Co-operative Tool Supply Company, Limited.—Capital £10,000 in £1 shares. Directors: Schalik, 41, Eton Avenue, London, N.W.3; S. Lourie, S. Beloff and H. Nassatiser.

G. W. Whall, Limited, 25, Johnstone Street, Ladywood, Birmingham.—Capital £1,500. Sheet metal workers. Directors: G. W. Whall (managing director) and W. O. Pamment.

H. H. Swann & Son, Limited, Cygnet Works, Copper Street, Sheffield.—Capital £5,000. Manufacturers and merchants of saws, tools, files, etc. Directors: H. H. Swann and E. H. Swann.

Eck & Brook, Limited.—Capital £3,000. Mechanical, technical, commercial or general engineers, etc. J. Eck, of 10, Priory Road, Bedford Park, London, W., is sole permanent director.

F. Davis, Limited, 106, Aston Road, Birmingham.—Capital £5,000. Metal and machinery merchants, etc. Directors: F. Davis (permanent governing director), J. Halford and G. Hodgkinson.

Birmingham Small Arms Company, Limited.—Preference dividends: "A" for the six months, 5 per cent. per annum (less tax); on "B" for six months, 6 per cent. per annum (less tax).

G. D. Peters & Company, Limited.—Net profit, £16,887; brought forward, £1,238; income tax, £8,966; balance, £9,159; preference dividend, 6 per cent., less tax, £6,918; carried forward, £2,240.

British Liquid Meter Company, Limited.—Capital £5,000. Directors: E. W. Lycett, F. E. Powell, J. Hamilton, and W. Cross. Secretary: R. Lycett, Seaforth, Monahan Avenue, Purley, Surrey.

Isaac Shaw, Limited, Aston Metal Works, 43 & 44, High Street, Aston, Birmingham.—Capital £20,000. Metal manufacturers and merchants. Permanent directors: I. Shaw (chairman) and L. I. Shaw.

Allan Kennedy & Company, Limited, 59, Dovecot Street, Stockton-on-Tees.—Capital £2,000. Manufacturers of special tools and fittings. Permanent directors: A. Kennedy (chairman) and C. Allan.

Groome & Company, Limited, 122, High Road, Kilburn, London, N.W.6.—Capital £200 in £1 shares. Metal and ores merchants. Directors: J. A. Groome, 17, Windsor Road, Willesden Green, London, N.W., and E. Moss.

Brush Electrical Engineering Company, Limited.—Net profit, £94,860; brought forward, £103,819; depreciation, £15,000; debenture interest, £2,045; income tax, £33,618; general reserve, £23,635; dividend, 10 per cent. per annum for year; carried forward, £78,525.

Penarth Pontoon, Slipway and Ship-repairing Company, Limited.—Brought forward, £6,046; profit, £5,534; interest on debentures, £1,560; two mortgage debentures paid off, £500; interim dividend paid, £1,272; final dividend, 3½ per cent., making 6 per cent. for year, less tax, £1,781; carried forward, £6,466.

Callendar Iron Company, Limited.—Capital £100,000 in £1 shares (25,000 preference and 75,000 ordinary), to acquire the business carried on at Falkirk and elsewhere by the Callendar Iron Company, Limited (in voluntary liquidation). Directors: M. Hay, H. Kidston and G. Moore. Secretary: R. L. Proudfoot, 6, Alva Street, Edinburgh.

James Cartland & Son, Limited.—Presiding at the annual meeting of this company at Birmingham on April 8, Mr. J. Howard Cartland expressed regret at the death of an esteemed colleague, Mr. C. Y. R. Bedford. Discussing the affairs of the company, he said they had now removed the whole of the manufacturing portion of their business to their Bordesley Green Works, and they looked forward with confidence to the result. Trade was still bad, the export trade in particular, and, owing to the political outlook, they were not receiving a reasonable share of the home market.

C. & W. Walker, Limited.—Mr. C. H. Wright (deputy-chairman), presiding at the annual meeting at Birmingham, made sympathetic reference to the loss the company had sustained by the death of their secretary (Mr. W. Cottrell). He said Mr. Cottrell had been at the works for over 49 years, and his last act before his sudden death was to prepare the balance-sheet. In moving the adoption of the report Mr. Wright mentioned that the company, in conjunction with two other firms, had taken over the patent rights for the construction in this country and the Colonies of a tankless gasholder, which, in the opinion of the directors, was the gasholder of the future.

Legal Intelligence.

Axle-Box Invention.

Mr. Justice Romer, in the Chancery Division last week, dismissed the action of Mr. G. Carson, of Hull, who asked to have set aside an agreement assigning to Mr. E. J. Wood, managing director of the Patent Axle-box and Foundry Company, Limited, of Wolverhampton, his rights in an invention relating to an axle-box for railway engines, wagons, and tramcars. Mr. Carson alleged that he had no independent legal advice when he signed the document, and it was not explained to him.

Giving judgment, Mr. Justice Romer said the plaintiff had no legal rights in the idea that was patented by Mr. Wood. All he did was to communicate to Mr. Wood an idea for lubricating axle-boxes which turned out to be old. Mr. Wood, however, combined the plaintiff's idea with his own in the device, and acted generously towards plaintiff, because he patented it in their joint names. If Mr. Wood had patented it in his own name the plaintiff could have made no legal objection. He was convinced that at the interview at Birmingham Mr. Wood explained to Mr. Carson that he wanted him to define his interests in the patent and that Mr. Carson understood the substance of the transaction to be entered into. He could not see that defendant had overreached plaintiff, or that he was responsible for any mistake the plaintiff had made. The action would be dismissed, but there would be an inquiry as to any profits accruing under the agreement.

Welding Law Case Settled.

Towards the end of December, 1922, Messrs. Alloy Welding Processes, Limited, and Ernest Henry Jones commenced an action against Messrs. Weldrics (1922), Limited, in respect of alleged infringement of Letters Patent 127,315 of 1917 and 157,534 of 1919.

The action was defended on the grounds that both of the said Letters Patent were invalid, and moreover that the defendants' electrodes were no infringement of either of the plaintiffs' Letters Patent. On March 12, 1924, the action being in the "Warned List" for trial, the plaintiffs applied for and were granted leave to discontinue the action as to both patents, and were ordered to pay the defendant's costs, and the plaintiffs further undertook to bring no further action in respect of the infringements complained of. In view of this Messrs. Weldrics (1922), Limited, will continue as before to manufacture and supply to their customers their brand of welding electrodes.

Parliamentary Notes.

Safeguarding of Industries Act.

Replying to Mr. Remer, Mr. Webb said that the Government had decided not to introduce legislation to extend the duration of the provisions of Part II of the Safeguarding of Industries Act which dealt with the making of Orders on the ground of depreciation of foreign currency. Those provisions, and the duties which had been imposed under them, would accordingly lapse on August 19 next.

Personal.

Mr. Clive L. Baillieu has been elected a director of the Zinc Corporation.

Mr. H. Stevenson has been appointed northern representative for George Wilson (Gas-Meters), Limited, of Coventry.

Mr. H. Rowland White has resigned from the board of Macready's Metal Company, Limited, 7, Baron Street, London, N.

YOU CAN TURN OUT
BETTER CASTINGS AT LESS COST
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SECTIONS OF STERLING ROLLED STEEL BAR AND STIFF SAND LEDGES, SHOWING THE SOLID RIB

SECTIONS OF STERLING ROLLED STEEL BAR AND STIFF SAND LEDGES, SHOWING THE SOLID RIB

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STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

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Telegrams: "LOWOOD, DEEPCAR."

SIEMENS' STEEL PROCESS

BOILER, SHIP and BRIDGE PLATES, etc. ANGLES and all forms of Sectional Bars. TYRES and AXLES to all requirements. CASTINGS of all kinds and of Largest Sizes. FORGINGS of every description. BILLETS, BLOOMS, RAILS.

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IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH. — In accordance with the customary conditions prevailing in this holiday season, very little business is negotiated in the week preceding Easter, and consequently interest in the Cleveland iron market has been on a minimum scale. The announcement of a relapse in the price of No. 3 G.M.B. came somewhat as a surprise to the market. The makers' position seems to be that while a few sales had been made at 95s., orders at this figure were not coming forward so freely, though this could well be accounted for by the weight of business which had come through during the previous week or two. However, one well-known firm reduced its quotation to 92s. 6d., and this has become the general figure, though it was certainly an absolute minimum. Current quotations meantime stand at 97s. 6d. to 100s. for No. 1; No. 3 G.M.B. at a minimum of 92s. 6d.; No. 4 foundry at about 92s.; and No. 4 forge, 91s. 6d. per ton. Both No. 1 and No. 4 foundry are very scarce.

Hematite continues very steady, notwithstanding the widening of the margin of price as compared with No. 3. East Coast mixed numbers are firm at 99s., with the No. 1 quality 100s. per ton. On the West Coast prices are unaltered, Bessemer mixed numbers being quoted at 112s. 6d. per ton delivered at Glasgow and Sheffield, and 117s. 6d. delivered at Birmingham.

MANCHESTER.—In this market sellers of pig-iron report that the inquiry for delivery over the quarter, say, from now until the end of June, is broadening, and it seems certain that a good deal more business will be done during April and May than during February and March. There is also, we believe, some improvement in the demand for castings, hence rather more business is being done in Derbyshire pig-iron on a basis of 95s. per ton at the furnaces. There are, however, some sellers now who ask 96s. to 96s. 6d., or equal to 103s. 6d. and 104s. per ton, delivered in Manchester.

THE MIDLANDS.—Makers in this area report that there is quite a fair demand for foundry numbers, consumers generally covering themselves for the remainder of the quarter. Buyers are, therefore, looking ahead, with the result that considerably more tonnage has been purchased from the Midland furnaces quite recently. The prices indicated below are quite firm; the makers will not concede a penny. Quotations are as under:—Derbyshire No. 3 foundry, 95s.; Staffordshire No. 3 foundry, 95s.; Northants No. 3 foundry, 92s. 6d.

SCOTLAND.—Conditions in the Scottish markets continue steady, with a better undertone, but so far the makers have not increased their prices. As concerns the home market, there is very little business passing, buying being principally of a hand-to-mouth character, although in one or two cases buyers are considering the question of purchasing ahead. One or two good lines have already been placed, and also some small orders for Scotch foundry pig-iron, with prices unchanged on the week.

Finished Iron.

The outlook in the manufacturing departments of the iron trade continues fairly satisfactory, makers of marked bars especially having sufficient specifications on hand to secure employment at the mills for some time to come. The bulk of the work in progress, both in this material and crown iron, is on order for railway rolling stock, of which a large quantity is urgently required by the various companies. In lower grade bars makers have not now to contend with such severe competition from abroad as was recently experienced, but could do with more orders to compensate for the loss of shipbuilding work, now suspended through the lock-out. Quotations:—Marked bars, £15 (net f.o.t. makers' works); crown bars, £13 upwards; nut and bolt bars, £12; gas strip, £13, all net delivered Birmingham area.

Steel.

At Sheffield, the cessation of Continental competition in billets, bars and sections is expected to be followed by a better demand for home productions, which, on the whole, are now much the same in price as the French and Belgian goods. Basic billets are showing signs of revival already, while acid billets are keeping up quite well. Prices are firm at £8 5s. to £8 10s.: soft basic billets, £10 intermediate and £10 5s. for hard: £12 10s. for Siemens acid; and £13 for Bessemer, all delivered Sheffield. Business in ferro-manganese has been slightly more active, but only for small parcels, many of which have been shipped to the Continent. Evidently consumers recognise that the makers have shown considerable restraint in not raising their prices beyond the £17 limit, and that the higher fuel values must produce a change very soon. The tone of the tinplate market generally is easier, and although those makers who are heavily booked (and they seem to be in the majority) are asking 24s. 6d. to 24s. 9d. per box there are sellers to-day at 24s. 3d. for June delivery, and most of the trade done recently has been on this basis.

Scrap.

Most of the consuming works having closed down for the holiday, there is very little business passing in scrap metals anywhere, and it must at least be another week before there is any active resumption of dealings. At the Manchester market foundry scrap does not respond to the better buying of foundry pig-iron, and this confirms the impression that the buying of that material does not mean any improvement in the demand for castings. There is plenty of good machinery scrap to be had here at 87s. 6d. per ton to 90s., but the demand is not at all equal to the supply, although the price is comparatively low. In Scotland heavy machinery cast-iron scrap is still quoted at 96s. to 97s. 6d. per ton, but the demand is poor. Ordinary heavy cast iron in handy pieces is 92s. 6d. per ton, although it has been bought for ironworks at about 90s. per ton. Old cast-iron railway chairs are being quoted at 96s. 3d. to 97s. 6d. per ton. Good clean light cast-iron scrap is 77s. 6d. to 80s., with firebars and light cast mixed at 75s. to 77s. 6d. per ton.

Metals.

Copper.—Movements in standard copper during the past week have reflected a steadier tendency, holiday influences doubtless having restricted business within narrow limits. Advices from America indicating a reduction in the stocks at the end of last month have also imparted some firmness to the market on this side. Consumption is moderately well maintained, but leaves room for considerable improvement. Stocks of copper at April 1 totalled 30,852 tons, an increase of 893 tons. Current quotations:—*Cash*: Wednesday, £64 10s.; Thursday, £64 12s. 6d.; Tuesday, £64 12s. 6d.; Wednesday, £64 7s. 6d.: *Three Months*: Wednesday, £65 7s. 6d.; Thursday, £65 10s.; Tuesday, £65 7s. 6d.; Wednesday, £65 2s. 6d.

Tin.—Although devoid of the sensational price developments recently marked in this metal, the general tone of the market has been depressed, with some irregularity in value fluctuations, a further fall of £15 being registered at the week-end. With so many conflicting influences operating it becomes increasingly difficult to form an opinion as to the course of the market. Much of the weakness arises from the fact that demand on the part of consumers is less urgent, and consumption, particularly in the U.S.A., tends to fall off. On the other hand, the technical position undoubtedly has been improved by the heavy liquidation and "bear" selling which have taken place. Statistics at the end of this month, by reason of the lighter shipments from the F.M.S. and possible heavy deliveries in the U.S.A., should make a favourable showing. Current quotations:—*Cash*: Wednesday, £249 5s.; Thursday, £247 5s.; Tuesday, £247 15s.; Wednesday, £248 10s. *Three Months*: Wednesday, £248 10s.; Thursday, £246 15s.; Tuesday, £247 15s.; Wednesday, £248 10s.

Spelter.—Quotations for this metal again evidence further weakness, while demand on the part of consumers has been disappointingly slow, and buyers in consequence have continued to adopt a very reserved attitude in face of the rather heavy liquidation which has taken place. The present level of price should, however, attract buying, and it seems not unlikely that consumers will take the opportunity to cover their requirements. Current quotations:—*Ordinary*: Wednesday, £32 12s. 6d.; Thursday, £32 12s. 6d.; Tuesday, £32 12s. 6d.; Wednesday, £32 13s. 9d.

Lead.—In the market for soft foreign pig, the tendency towards lower values has been continued, particularly for forward delivery, which has been freely offered. The backawardation has lengthened. A fair amount of liquidation has again been in evidence, and the falling market and the rather depressed condition of metals generally have encouraged "bear" selling. Consumption is fairly well maintained, but conditions remain a little easier as regards supplies, and the tendency of the market continues uncertain. Current quotations:—*Soft foreign (prompt)*: Wednesday, £32; Thursday, £32 5s.; Tuesday, £32 15s.; Wednesday, £32 15s.